Africa Research in Sustainable Intensification for the Next Generation

Sustainable intensification of key farming systems in east and southern Africa

Technical Report
01 April–30 September 2018

Submitted to
United States Agency for International Development (USAID)

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November 2018

www.africa-rising.net

The Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research-for-development projects supported by the United States Agency for International Development as part of the U.S. government's Feed the Future initiative.

Through action research and development partnerships, Africa RISING will create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three regional projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads the program's monitoring, evaluation, and impact assessment. http://africa-rising.net/

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This document was made possible with support from the American people delivered through the United States Agency for International Development (USAID) as part of the US Government's Feed the Future Initiative. The contents are the responsibility of the producing organization and do not necessarily reflect the opinion of USAID or the US Government.

Contents

Partners

ADD	Agriculture Development Division, Malawi
AFRISEED	Afriseed-Steward Globe Limited (Zambia)
AGRA	Alliance for a Green Revolution in Africa
ARI-Naliendele	Agricultural Research Institute, Naliendele, Tanzania
ARI-Hombolo	Agricultural Research Institute, Hombolo, Tanzania
ARI-Selian	Agricultural Research Institute, Selian, Tanzania
AVRDC	The World Vegetable Center
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Centre
COMACO	Community Market for Conservation
CRS	Catholic Relief Service
DACO	District Agricultural Coordinator Offices (Zambia)
DAICO	District Agriculture, Irrigation and Cooperative Offices (Tanzania)
DALDO	District Agriculture and Livestock Development Offices (Malawi)
GART	Golden Valley Agricultural Research Trust
ICRAF	International Center for Agroforestry Research
-	Grassroots Trust, Zambia
ICRISAT	International Crops Research Institute for the Semi-arid Tropics
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
LUANAR	Lilongwe University of Agriculture and Natural Resources, Malawi
MSU	Michigan State University
MAFC	Ministry of Agriculture, Food and Cooperatives, Tanzania
MERU- AGRO	MERU-AGRO Seed Company
MMFL	Minjingu Mines and Fertilizer Company
NAFAKA II	Cereals market System Development (Tanzania)
NM-AIST	Nelson Mandela African Institution of Science and Technology
PROFIT+	Production Finance and Improved Technology Plus
SAIOMA	Strengthening Agricultural Input and Output Markets
SFHC	Soils, Food and Healthy Communities, Malawi
SCCI	Seed Certification and Control Institute
SHARE	SHARE Africa, Zambia
TALIRI	Tanzania Livestock Research Institute
TARI	Tanzania Agricultural Research Institute
TLC	Total Land Care (Zambia)
UDOM	University of Dodoma, Tanzania
UNZA	University of Zambia
ZamSeed	Zambia Seed Company
ZARI	Zambian Agriculture Research Institute
WU	Wageningen University, The Netherlands

Summary

Several impressive successes were achieved by the Africa RISING ESA project team this year as enumerated below.

1. In Tanzania, the evaluation of new, elite material of different stress-tolerant crops has been finalized and variety release proposals based on performance across seasons for both on station and on farm were developed and submitted to the Tanzania Agricultural Research Institute, which is responsible for their release. The crops are groundnut varieties ICGV-SMs 03519, 05650, and 02724; sorghum varieties Gambela 1107, IESV 92028, and IESV 23010; and pearl millet varieties SDDV 96053, IP 8774, IP 96053, KAT PM2, IP 9976, and SMDV 94605. Evaluation of early, intermediate, and late drought tolerant, new, elite maize hybrids was also implemented for further analysis for genotype × environment interactions and stability. Informal seed systems were used as alternatives for producing seed necessary for scaling out released, but not readily available, varieties to farmers, given that seed agencies were not ready to multiply seed of these crops except for maize, the staple. Meru-Agro and Drylands Agricultural Investment Limited Seed Companies are producing hybrid and foundation seed for Quality Protein Maize (QPM). Demonstrations were also implemented, including in Malawi, to promote good agronomic practices as being necessary for achieving production potential of new crop varieties.

2. Studies on enhancing adaptation for resilience through manipulation of cereal/legume configurations were implemented in all three ESA project countries. The evaluations were cognizant of the coming on board of the Sustainable Intensification Indicator Framework (SIIF) guidance for technology validation, and generated data on productivity, economics, the environment, and gender. The nutrition research utilizes the new crop materials to formulate nutritive food rations, thereby contributing to informing the human condition component as guided by the SIIF. Nutrition scientists were disappointed to note increased stunting of children after the experimental feeding period ended, an indication of weak technology adoption. This warrants further investigation to understand determinants of adoption of nutrition interventions.

3. Some of the introduced crops were also used in formulating home-made feed rations for poultry under housing and free-range conditions. These rations did not only decrease feeding costs, but also improved growth rate by 53% more than the scavenging chickens at 20 weeks of age. Partially housed local chickens complimented with formulated rations gained 253 g (29%) over the full-time outdoor scavenging chickens at the age of 20 weeks.

4. In a similar study with goats, data suggests that within 60 days of feeding, goats gain weight twice as fast when fed on supplementary diets that include both *Faidherbia* pod and *Gliricidia* leaf components.

5. There were continued data collections on in-situ (Tanzania and Malawi) and conservation agriculture (CA - Zambia) land management systems, and their associated technologies. In Zambia, it was concluded that a full groundnut with half the pigeonpea

is the best doubled-up legume associate technology to CA as it reduced labor requirements for land preparation.

6. Studies on resource and carbon transfers within and between farms used regression trees to confirm that inclusion of either livestock or land/farm implement variables had the greatest effect on resource flows. Resource flow scores increased with livestock ownership and farmers with very low livestock numbers (< 1.6 units for livestock ownership) are net exporters of organic resources. Overall, increased ownership of land and farm implements is associated with increased organic resource importation.

7. The approach of using ICTs for linking farmers to markets is generating strong interest. Data collected on the continued test implementation of the MWANGA platform in Babati reveals that 85% of the farmers who received the messages had found them useful, despite a few challenges that need to be overcome, like distinguishing MWANGA messages from those of telemarketers. There has been further development of an android APP for the MWANGA platform for sharing agronomic, market, and climate services information with farmers.

8. There are two successful examples of how Africa RISING is collaborating with development partners in delivering technologies to scale. They are partnerships with Catholic Relief Services (CRS), which has invested financial resources in Zambia and Tanzania, and Islands of Peace, who have also invested financial resources to deliver technologies in Karatu District of Tanzania. These examples are driving other members of the Africa RISING consortium to identify from the mapped value chain stakeholders, those development institutions that are willing to join hands with Africa RISING to take their technologies of interest to scale and can support this process.

Africa RISING ESA project action sites

Figure 1 shows the ESA-wide geo-referenced sites where Africa RISING implemented research or technology dissemination activities during the reporting period.

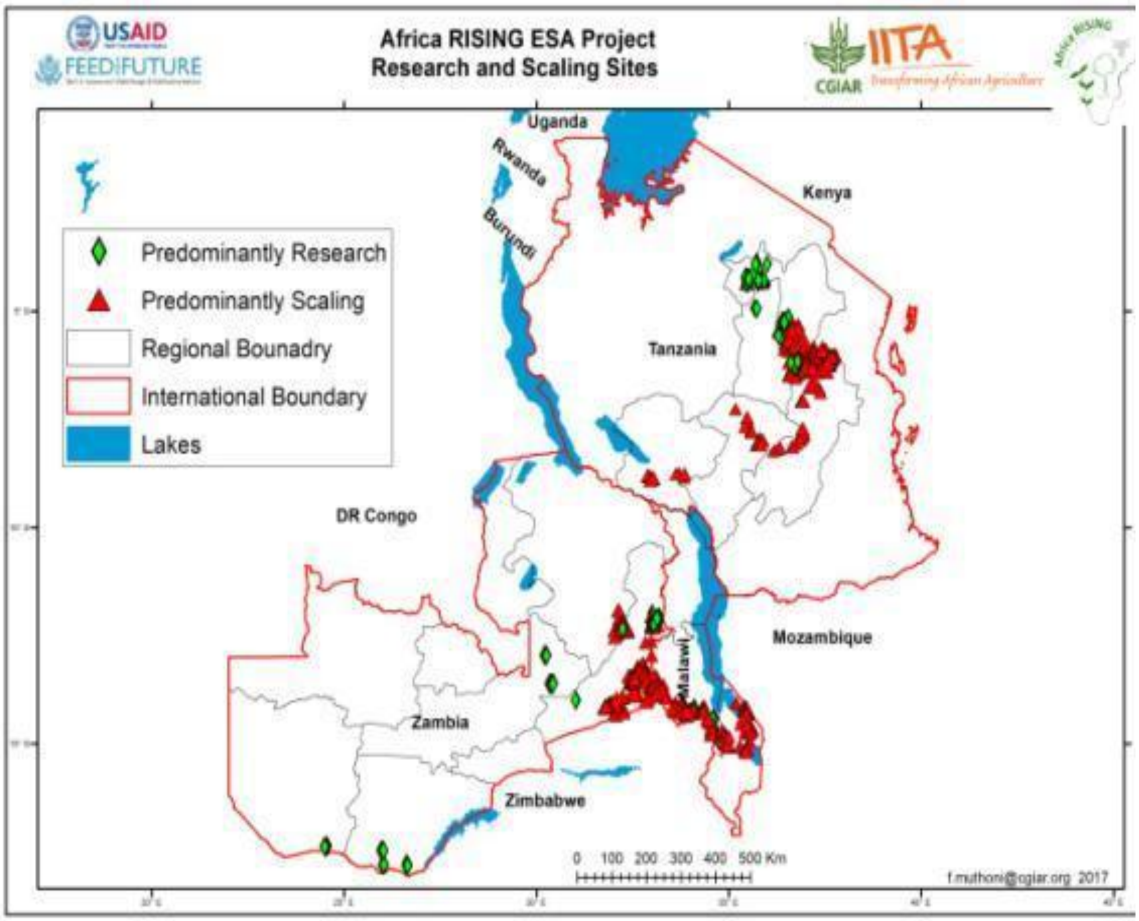

Figure 1. Present locations of research (green diamond) and scaling (red triangle) sites in ESA.

Implemented work and achievements per research outcome

Outcome 1. Productivity, diversity, and income of crop–livestock systems in selected agroecologies enhanced under climate variability

Deploying new crop varieties for diverse crop–livestock systems

Groundnut

The third evaluation of elite material, a requirement for variety release has been finalized; this year varieties were evaluated at eight sites in Dodoma and Iringa regions. The three candidate lines (ICGV-SMs 03519, 05650; Spanish and short duration and 02724; Virginia and medium duration) were tested against *Mnanje*, a Virginia variety released in 2009 in Tanzania. Overall results show significant differences in yield, $P \leq 0.05$ (Table 1). ICGV-SM 02724 remained the best genotype followed by ICGV-SM 03519 with a kernel yield of 1486 kg/ha and 1127 kg/ha, respectively. ICGV-SM 02724 had a yield advantage of 64.93% over *Mnanje*. Farmer selection showed ICGV-SM 02724 as the most preferred genotype, chosen for its high yielding ability, big seed size, and drought tolerance. All the genotypes have good confectionery traits like good seed size, ease of blanching, good seed quality, and taste, amongst others. Figure 2 shows the three genotypes proposed for release. A variety release proposal based on performance across seasons for both on station and on farm was developed and submitted to the Tanzania Agricultural Research Institute (TARI), Naliendele Station.

Table 1. Performance of candidate groundnut genotypes proposed for release in Tanzania.

Genotypes	Kernel yield (kg/ha)	Yield advantage (%)	Farmer rank	Farmer preference
ICGV-SM 02724	1486	64.93	1	High yielding, big seed size, drought tolerance
ICGV-SM 03519	1127	25.08	2	Good taste, drought tolerance
ICGV-SM 05650	970	7.66	3	High yielding, drought tolerant
Mnanje	901	0	4	Big seed size
Mean	1121			
Fpr	< .001			
Sed	112.4			
CV%	22.4			

Figure 2. Photographs depicting grain and pod characteristics of the three groundnut lines proposed for release. Photo credit: Patrick Okori/ ICRISAT.

Pigeonpea

Activities with pigeonpea were aimed at scaling-out released but not readily available varieties to farmers in Kongwa and Kiteto. Focus varieties included ICEAPs 00040 (Mali), 00554 (Ilonga 1), and 00557 (Ilonga 2). Mali has already been rolled-out through an informal seed system in which farmers are trained to produce and manage quality seed that is shared in their communities. The performance of Ilonga 1 and 2 is being validated in Kongwa and Kiteto and seed is being bulked for deployment. Results for the 2017/18 season show significant differences, ($P \leq 0.05$), in the performance of varieties for both grain yield and 100 g seed mass (Table 2). ICEAPs 00557 and 00554 were the highest yielders with yields of 1210 and 1199 kg/ha respectively. ICEAP 00040 and the local check performed poorly. The poor results for ICEAP 00040 may be attributed to the low rainfall that may have not been enough for this long duration maturing pigeonpea genotype. The G × E biplot shows that ICEAPs 00557 and 00554 are well adapted to six of the seven test sites, implying that they have wide adaptation. Laikala was the worst environment for this season. ICEAPs 00557 and 00554 were also the most stable genotypes (Fig. 3).

Table 2. Performance of pigeonpea varieties in Kongwa and Kiteto districts of Tanzania.

Genotype	Grain yield (kg/ha)	100 g seed mass
ICEAP 00040	254.6	15.33
ICEAP 00554	1199.1	17.22
ICEAP 00557	1210.6	17
Local Check	71.8	12.03
Mean	684.03	15.5
Fpr	< .001	0.007
Sed	274.332	1.49
CV%	85.1	20.5

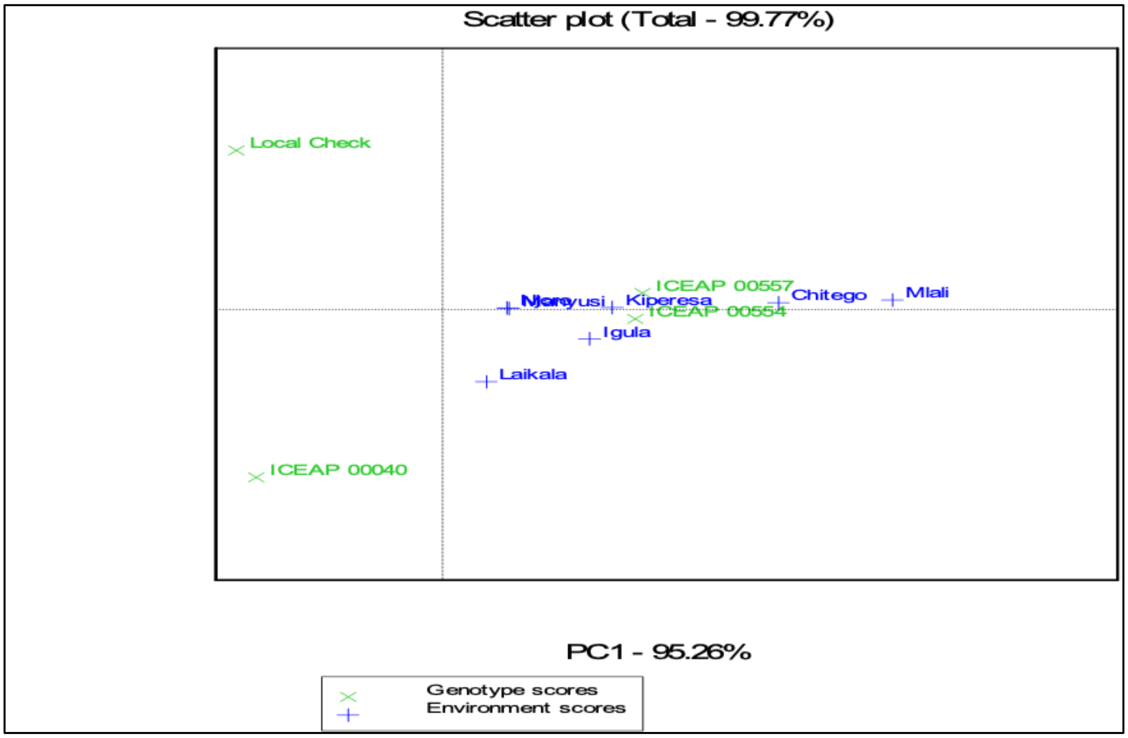

Figure 3. Genotype × Environment (Village) biplot for pigeonpea in Kongwa, Kiteto, and Iringa districts of Tanzania.

Sorghum

Three candidate lines of sorghum (Gambela 1107, IESV 92028, IESV 23010) proposed for release were planted in Kongwa, Kiteto, and Iringa districts of Tanzania. Results show significant differences P < 0.05 for both grain yield and 100 g seed mass (Table 3). IESV 92028 DL was the best performer with grain yield of 1643 kg/ha) and 68.85% yield advantage over the local check (Lugugu). The test-line IESV 23010 DL had the largest seed size (3.0 g) followed by Gambella 1107 (2.55 g). Across seasons analysis shows that Laikala was the better environment for discriminating test sorghum material, and that Gambella 1107 was the most stable genotype. A variety release proposal has been developed and submitted to the TARI, Ilonga Station, for processing national variety release.

Table 3. Performance of new sorghum lines proposed for release.

Genotype	Grain yield (kg/ha)	Number of ears	Yield advantage	Scores	Rank	Reasons for high ranking
Gambella 1107	4604	124.8	44.2	117	1	Panicle size, seed size
IESV 23010	3923	160.5	22.8	99	3	Panicle size
IESV 92028	4080	180.2	27.7	104	2	Panicle size
Lugugu (Check)	3194	166.0				
Mean	3950.3	157.9				
Fpr	0.017	0.003				
Sed	398.6	13.1				
CV%	17.5	14.3				

Pearl millet

Six lines (SDDV 96053, IP 8774, IP 96053, KAT PM2, IP 9976, and SMDV 94605) were evaluated in Kongwa, Kiteto, and Iringa districts. Performance results show significant differences, $P < 0.05$ for grain yield; all test lines outperformed the local check, with yield advantage ranging from 25.4% to 95.7% (Table 4). There were no significant differences for the number of ears, and the weak correlation coefficient ($r2 = 0.15$) between grain weight and number of ears implies that an increase in number of ears did not necessarily increase the grain yield. The order of performance from best to least is as follows: SDMV 96053, SDMV 94005, IP 8774, IP 9776, SDMV 96063, KAT PM 2, and SDMV 95005. The test site in Laikala village, Kongwa District received the least rainfall of about 357 mm and it is here that genotype IP 8774 performed well. This suggests that this genotype may be the most drought tolerant, which tallies with farmer ranking. A variety release document has also been developed for the six genotypes and forwarded to TARI Ilonga Station to consider them for release.

Table 4. Performance of new pearl millet lines proposed for release.

Genotype	Grain Yield (kg/ha)	No of ears	Yield advantage	Overall scores	Farmer selection	Main reason (s)
IP 8774	1491	155.7	90.5	95.43	3	Drought
SDMV 96063	1423	171	51.4	55.34	5	Earliness
IP 9976	1433	254.2	52.4	55.94	6	Drought
KAT PM2	1204	185.5	28	50.33	7	Earliness
local	940	159.5	0	17.23	8	Drought
SDMV 94005	1518	253	61.5	99.45	2	Panicle size, earliness
SDMV 95005	1179	206.5	25.4	75.41	4	Drought
SDMV 96053	1840	201.8	95.7	104.55	1	Panicle size, earliness
Mean	**1347.8**	**195**				
Fpr	0.002	0.114				
sed	330.39	54				
CV%	30	33.9				

Maize

Early, intermediate, and late drought tolerant (DT) new, elite maize hybrids were evaluated for adaptability under semi-arid conditions at seven sites in Kongwa (2), Kiteto (1), and Iringa (4) districts. The results show that most new DT maize hybrids; early, intermediate, and late, had higher yield and agronomic performance under conventional/farmer tillage practices than farmer-preferred maize varieties used as a local check. Performance of the top four hybrids from each category are presented in Table 5. Further analysis for genotype × environment interactions and stability is in progress.

Table 5. Yield and agronomic performance of drought tolerant hybrids in Kongwa and Kiteto in 2018. The first 4 ranked hybrids are presented by maturing category.

Hybrid Name	Grain yield (MT/ha)	Rank	Lodging (Root, %)	Lodging (Stem, %)	Ears (/plant)	Ear rot (%)	Grain moisture (%)	Ear Aspect (1-5)
Early maturing								
CKDHH170114	4.6	1	21	26	1.0	0	14.5	1.0
CKDHH170346	4.6	2	15	13	1.0	0	14.1	1.0
CKH160231	4.3	3	10	21	1.3	2	14.7	1.0
CKH160277	4.2	4	6	54	1.2	2	14.7	1.5
Early-intermediate maturing								
CKDHH1600016	3.2	1	3	0	1.0	2	14.8	1
CKH160169	2.8	2	0	3	0.9	5	14.0	1
CKH160150	2.6	3	10	7	1.0	2	13.7	1
CKDHH160145	2.6	4	0	-1	1.0	2	14.3	1
Intermediate-late maturing								
CZH15043	4.4	1	0	4	1.0	0	17.0	1.3
CKH10767	4.7	2	1	6	1.1	2	17.0	1.0
WH505	4.8	3	0	6	1.0	10	17.8	1.3
EASH1129	4.6	4	0	8	1.0	0	17.1	1.0

Pathways for improving access to seeds of modern and traditional crop varieties

Community Seed Bank systems

An informal system that operates via Community Seed Banks (CSBs), a mechanism of choice for scaling out seed and allied technologies of under-invested crops, was applied to the focus crops—the released varieties of pigeonpea, sorghum, and pearl millet. Table 6 shows continuity in terms of seed pay-back and "pass-on" to new farmers. Data collected so far show a total of 8573 kg of pigeonpea seed was produced in the 2016–2017 season with about 1184 kg being the amount paid back to the seed bank and distributed to 592 new beneficiaries during 2017–2018. For pearl millet, 686 kg of seed was produced from an initial 50 kg, and 28 new beneficiaries have accessed seed while for sorghum, a total of 2296 kg were produced in Moleti, Kongwa District, and 40 new farmers have accessed seed banks. Data collection delays results from relying more on the lead-farmer and or seed bank chairpersons and in many villages, mobility has been the major limiting factor.

Table 6. Seed production and pass-on to new beneficiaries through community seed banks.

No	Village Name	Crop	Amount of Seed harvested (kg) in 2016/2017	No of beneficiaries for 2017/2018	Amount of Seed harvested (kg) in 2017/2018
1	Njoro	Pigeonpea	778	165	Being collected
2	Moleti	Pigeonpea	2,721	120	Being collected
3	Manyusi	Pigeonpea	317	43	Being collected
4	Chitego	Pigeonpea	95	95	Being collected
5	Mlali	Pigeonpea	4,202	118	Being collected
6	Laikala	Pigeonpea	460	51	Being collected
		Total	**8573**	**592**	
7	Laikala	Pearl millet	686	28	Being collected
8	Moleti	Sorghum	2,296	40	Being collected

Quality declared seed

In Malawi, the Seed Services Unit systematically sampled seed produced by farmers as part of the seed certification process. This was the last stage of the field activities, following the field inspection that had been completed during January–March. The samples are currently being processed for seed viability and purity at the Seed Services Unit laboratories at Chitedze Research Station.

During May 2018, yield cuts were conducted as part of productivity estimates resulting from farmer use of improved seed with the recommended agronomic practices (Fig. 4). This was designed to quantify productivity of the legumes when germplasm and general agronomy are good in different sites (G × E × M). Average yields obtained were > 1,000 kg/ha, except for Ntubwi EPA that had poor yields due to a severe drought, as compared to < 700 kg/ha normally achieved by farmers. Many baby farmers have gradually implemented technologies at farm scale, graduating from plot scale, which was the farmer engagement entry point. This self-led scaling is what is important for sustainable adoption of technologies.

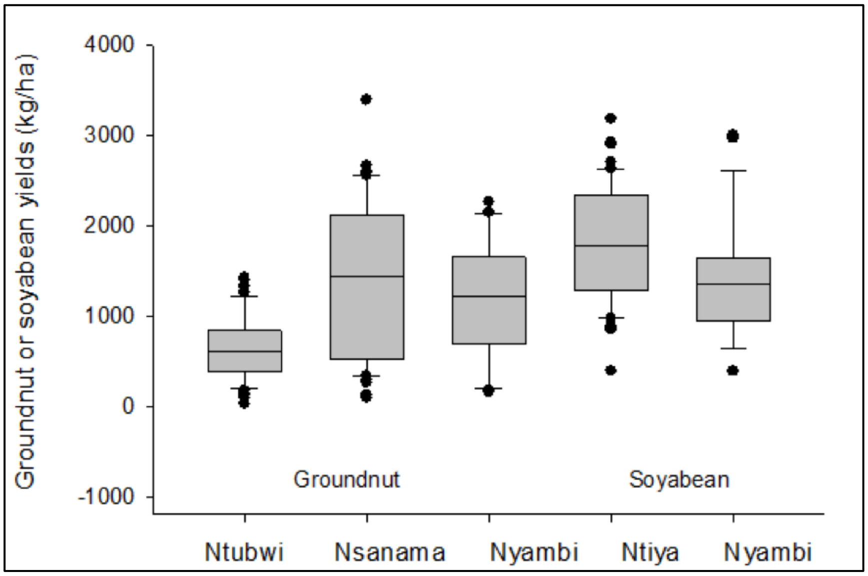

Figure 4. Productivity of groundnut and soybean as determined by yield cuts during May 2018, for different study sites—EPAs (Ntubwi, Nsanama and Nyambi in Machinga District, and Ntiya in Mangochi District). Yield cut measurements involve taking three net plots across a field diagonal, each net plot being 2 rows × 2 m long. Net plot is a function of each farmers' row spacing. The number of fields sampled varied from 27 in Nyambi to 57 in Ntubwi. This data excludes outliers. Groundnut was grown in Ntubwi, Nsanama, and Nyambi, while soybean was grown in Nyambi and Ntiya. Groundnut productivity was very poor in Ntubwi due to an extended drought and high temperature.

Strategic partnership with local administration for scaling-out seed

In the 2016–2017 cropping season the Kongwa District Council received 25 kg of sorghum seed and produced 500 kg of Quality Declared Seed (QDS). That seed was distributed to 165 farmers as first beneficiaries during the current cropping season. The District Council is yet to provide information on production, productivity, and projected number of new beneficiaries.

Bulking seed in readiness for release

Early generation seed of pigeonpea, groundnut, pearl millet, and sorghum were bulked to underpin establishment of functional seed systems for the central semi-arid zones of Tanzania. A summary of the results is presented below:

Groundnut

This is seed of newly released varieties for which breeder seed was bulked:

1. ICGV-SM 02724 – 700 kg
2. ICGV-SM 03519 – 200 kg
3. ICGV-SM 05650 – 40 kg

Pigeonpea

These are already released varieties: Seed was bulked by Dry Land Agriculture Investment Limited (DIAL) in Morogoro with the following outputs:

1. ICEAP 00040 (Mali) – 1000 kg
2. ICEAP 00554 (Ilonga 1) – 1000 kg
3. ICEAP 00557 (Ilonga 2) – 1000 kg

Sorghum
Five kilograms each of nuclear seed, the earliest generation of seed for five candidate genotypes proposed for release in Tanzania, i.e., Gambella 1107, IESVs 23010 DL, 92028 DL, 92008, and 23006, have been multiplied in Nairobi.

Pearl millet
Five kilograms each of nuclear seed, the earliest generation of seed for six candidate genotypes proposed for release in Tanzania i.e. (KAT PM2, SDMV 96063, SDMV 96053, SDMV 94005, IP 8774 and IP 9676) has been multiplied in Nairobi.

The project is bulking seeds for parents of the AR-released QPM hybrids (CZH132019Q and CZH132003Q) for Tanzania in collaboration with Meru-Agro Seed Company. Four parental lines and two single crosses were planted to bulk seed in the 2018 season. Table 7 is a summary of the seed quantities of the bulked parents and single cross. These will be grown in 2018/19 to make basic seed.

Table 7. Seed quantities of Quality Protein Maize parental lines and single cross seed bulked by Meru-Agro.

Parental lines			**Single crosses**	
Name	**Type of seed**	**Weight (Kg)**	**Name**	**Weight (Kg)**
CZL1311	Type A (selfed)	1	CZL1311/CML491	3.5
	Type B (selfed)	0.5	CML491/CZL082	4
CML491	Selfed	5		
CZL082	Type A (selfed)	4.5		
	Type B (selfed)	5		
CZL134	Selfed	5.5		

Performance of recycled seed
In Malawi, six graduate student experiments were established in Linthipe EPA (Dedza District) and Ntubwi EPA (Machinga District) to determine performance of farmer recycled seed (yield gap analysis - improved seed vs > 5 generations farmer retained seed). This study was disbanded because the "retained" seed was not true to type; it was a mix of different varieties.

Improving legume seed delivery systems in Zambia

Breeder seed
During the season, ICRISAT in collaboration with ZARI, planted groundnut breeder seed on 7.4 ha from which 4.6 tons(t) were produced. This was an under-achievement on the targeted 12 t due to early-season drought; 2.5 t of soybean and 1.8 t of cowpea breeder seeds were produced.

Foundation seed
Production of groundnut and pigeonpea foundation seed was implemented by both the project and by partners. Groundnut and pigeonpea breeder seed were made available for sale to partners to produce foundation seed. By the end of the planting season, 19.3 ha of groundnut and over 2.0 ha of pigeonpea were planted. By this reporting period, 14.8 tons for groundnut

and 0.95 tons for pigeonpea seed have been produced. The groundnut seed target was met while the one for pigeonpea is likely to, given that seed harvesting is ongoing

Quality Declared Seed (QDS)

As stated in the previous report, Zambian companies involved in legume certified seed production are not yet fully on board and considering that it would take time for certified seed to be produced once they come on board, the Community Seed Bank (where QDS is produced through farmer groups of 10–20 members) approach was implemented. Farmers took seed loans from the project to pay back to the seed producer groups at double the amount of the loan. During the season, farmers took seed loans of 5 kg for groundnut and 2 kg for pigeonpea per farmer. Five seed banks per district took seed to produce QDS. About 900 kg of groundnut seed was taken by 180 farmers, including 157 women and 53 men. Pigeonpea seed taken amounted to 342 kg and benefited 171 farmers, including 123 women and 48 men. The amount of seed produced was 7.2 t for groundnut and 12.95 t for pigeonpea. The target of 150 seed producers was exceeded, though productivity was affected by lack of rain. Good Nature Agro Ltd procured basic seed of soybean (Kafue) from IITA and produced certified seed amounting to 300 t.

Promoting good agronomic practices (GAPs)

To impart knowledge and enhance adoption of the improved varieties and crop management practices for the target crops, ICRISAT established on-farm demonstration/learning plots in the target sites. These were 18 groundnut demonstrations (demos) (variety × crop management) involving five varieties (Wamusanga, Wazitatu, Lupande, MGV 6, and MGV 7), as well as 18 pigeonpea demos using five varieties (ICEAP 00557, ICEAP 00554 [MPPV 2], ICEAP 1485/5, Mthawajuni, and ICEAP 01415/15).

For groundnut, the results show highly significant differences ($P > 0.001$) between varieties, which can be attributed to differences in their diverse genetic potentials. Planting pattern was also highly significant ($P > 0.001$) indicating that planting of double rows is beneficial as it leads to higher yield compared to single row planting (Table 8). There was, however, no interaction between variety and number of rows per ridge. The highest increase in yield resulting from doubling rows was attained by the low yielding variety Wazitatu, and the least increase by high yielding variety Lupande.

Table 8. Grain yield of different groundnut varieties under single and double rows planting per ridge.

Variety	Planting pattern		Mean	% increase over single row
	Double row	Single row		
Lupande	1368	1209	1288	13
MGV6	1236	728	982	70
MGV7	1075	658	867	63
Wamusanga	1185	881	1033	35
Wazitatu	1016	590	803	72
Mean	**1176**	**813**		
LSD variety	**177.4**			
LSD planting pattern	**112.2**			
%CV	**32.40**			

Seed management software

An excel-based software that has formulae for different transactions in seed management to deal with entries from the field, and warehouse receipts (for entry and exit of seed from the warehouse) was installed in computers for use by the ZARI's Msekera Research station (MRS). This means that MRS can now easily provide seed stock in real time and track all seed movement. Nine staff (7 male, 2 female) were trained on the use of the software.

Deploying integrated community breeding for resilient and more productive poultry in Kongwa and Kiteto districts of Tanzania

Deployment of improved dual-purpose breeds

Because of limited funding, activities under this research were suspended during this reporting period.

Enhancing resilience adaptation through cereal/legume cropping systems

Mbili-mbili and other maize and legume intercrop configurations in Babati, Tanzania

i. Productivity

Six on-farm trials with seven treatments each were initiated in villages with varying agroecological conditions being Sabilo, Ayamango, and Endanoga, all in Babati District of Tanzania. Maize grain yield ranged from 1.0 to 4.3 t/ha (Table 9). There were significant differences in maize grain yields between the sites. However, there were no significant statistical differences in maize yields between the treatments. Bean yields from two of the seven treatments being tested (i.e., Mbili-mbili and doubled-up legume) ranged from 0.1 to 1.5 t/ha. As expected, the doubled-up legume system achieved higher bean yield than mbili-mbili intercropping, attributed to shading differences.

Generally, pigeonpea yields ranged from 0.5 to 2.6 t/ha across the sites. In Sabilo village ("Farmer 2" field), pigeonpea was significantly affected by spatial manipulation and topping of maize plants. At this site, doubled-up legume, planting two maize seeds per hill at a spacing of 50 cm by 50 cm (topped at physiological maturity) and mbili-mbili intercropping had the highest pigeonpea productivity.

ii. Economics

With design involving multiple crops in different configurations, it is profitability that captures the overall performance of the cropping system that is of interest. Gross margins ranged from US$235 to 1658 (Table 10). Practicing continuous maize was the least profitable system (except in 2 sites) compared to maize–legume intercropping. This can be attributed to more benefits being accrued from the sale of multiple crops compared to a sole crop. Besides, utilizing pigeonpea as an intercrop generates more income through the sale of grains for food and woody stems for fuel and fencing materials, while husks are blended with sunflower seedcake to make livestock fodder.

Table 9. Effect of crop configurations on maize, pigeonpea, and bean production in different farmer fields in 2018 in Babati, Tanzania (village names in brackets).

Crop configuration	Farmer 1 (Orngadida)		Farmer 2 (Sabilo)		Farmer 3 (Orngadida)		Farmer 4 (Orngadida)		Farmer 5 (Endanoga)		Farmer 6 (Sabilo)	
	PP	*Mz*	*PP*	*Mz*	*PP*	*Mz*	*PP*	*Mz*	*PP*	*Mz*	*PP*	*Mz*
M_515 (No legume)		1		3.1		3		3.9		2.6		4.1
M_513/pigeonpea (no topping)	1.9[a]	1.2	1.2[abc]	3.3	0.8[ab]	2.8	0.7[a]	3.1	0.8[a]	2	1.9[ab]	3.9
M_515(2 plants/hole)/pigeonpea (Topped)	1.9[a]	1.6	1.5[cd]	3	0.6[ab]	2.4	0.8[a]	4.1	1.2[ab]	1.9	1.5[ab]	4
M_515_Mbili-mbili	2.3[a]	1.3(0.55)	1.3[bcd]	2.7(0.1)	0.5 [a]	1.9	0.5[a]	3.3	1.4[ab]	1.9	0.9[a]	3.8(0.11)
M_515/pigeonpea (Topped)	1.9[a]	1	1.1[ab]	3.1	0.8[ab]	2.3	0.8[a]	2.7	1.8[ab]	2.3	1.1[ab]	3.9
M_515/pigeonpea (no topping)	2.4[a]	1	0.9[a]	2.9	1.1[b]	2.6	0.5[a]	3.7	2.0[b]	2.1	1.5[ab]	4.3
Doubled-up Legume	1.9[a]	(1.5)	1.5[d]	(0.37)	0.8[ab]		0.9[a]		1.9[ab]		2.6[b]	(0.85)
LSD	**0.8**		**0.3**		**0.5**		**0.6**		**1.2**		**1.7**	

<u>**Notes:**</u> PP = Pigeonpea; Mz = Maize; numbers in brackets are yield of common beans. In some fields the common bean was destroyed by excess water, so gave no yield. Within a column, pigeonpea values followed by the same letter are not statistically different at $P < 0.05$. No differences were observed for maize.

Table 10. Gross margins obtained for the different crop configuration treatments implemented in Babati in 2018.

Treatments	Farmer 1	Farmer 2	Farmer 3	Farmer 4	Farmer 5	Farmer 6
M_515 (no legume)	234.9[a]	472.4[a]	575.9[ab]	494.3[a]	401.1[a]	487[a]
M_513/pigeonpea (no topping)	1156[b]	1068.1[bc]	876.7[bc]	736.3[ab]	742.5[abc]	1525[b]
M_515/pigeonpea (topped)	1167[b]	1092.1[bc]	704.6[abc]	865.3[ab]	1127.9[bc]	1114[ab]
M_515/pigeonpea (no topping)	1391[b]	944[b]	1034.1[c]	699.2[ab]	1186.5[c]	1540[b]
M_515_Mbili-mbili	1621[b]	1048.2[bc]	559.7[ab]	766.2[ab]	972.8[abc]	985[ab]
M_515 (2 plants/ hole)/pigeonpea (topped)	1425[b]	1199.1[c]	761[abc]	979.8[b]	696.3[abc]	1235[ab]
Double-up Legume	1592[b]	935.8[b]	399.2[a]	454.7[a]	602.4[ab]	1658[b]
LSD	**194.8**	**251**	**435.3**	**480.4**	**579**	**896.2**

<u>**Note:**</u> Means followed by the same letter in column are not significantly different at $P < 0.05$ probability level.

iii. Soil water infiltration

Tests were carried out at field level using minidisk infiltrometers at two suctions i.e., –2 cmsec-2 (i.e., through macropores of about 1.45 mm diameter) and –6 cmsec-2 (micro-pores of about 0.48 mm diameter). The infiltration rates varied from field to field ranging from 1.1 to 0.45 mmsec-2 for macropores and 0.04–0.01 mmsec-2 for micropores (Table 11). High macropore infiltration rates are associated with high organic matter (e.g., field located in a bottomland and homefield). The low infiltration, e.g., at "Farmer 3" field is characterized by clay loam often associated with slow water infiltration. In such a field, application of residue and/or manure is important to improve soil structure and increase soil pore volume for increased soil moisture storage.

Table 11. Effects of farm management on soil water infiltration rates in eight farmer fields in Babati, Tanzania, during the 2018 cropping season.

Farmer ID	Infiltration rate (mm/sec^2) in macropores	Infiltration rate (mm/sec^2) in micropores
Farmer 1	0.47^{a}	0.012^{ab}
Farmer 2	0.69^{a}	0.013^{abc}
Farmer 3	0.45^{a}	0.01^{a}
Farmer 4	1.1^{a}	0.04^{d}
Farmer 5	0.49^{a}	0.021^{bc}
Farmer 6	0.78^{a}	0.024^{c}
Farmer 7	0.77^{a}	0.014^{abc}
Farmer 8	0.9^{a}	0.015^{abc}

Note: The last 2 farmers are additional over those where trials were conducted in 2018. Means followed by the same letter in column are not significantly different at P < 0.05 probability level.

iv. Gender equity (rating of technologies by gender)

Trial-host farmers (two of them female) ranked the seven technologies (treatments) tested in their own fields based on four key criteria of crop performance/yield, labor demands in implementation, expected profitability, and contribution to food security. They also provided an overall rating. Planting two maize seeds at an intra-row space of 50 cm (also maize topped at maturity) was most preferred in terms of yield production and in the overall preference (Table 12). The mbili-mbili system was ranked as the most profitable and food-secure technology as a result of high plant density, i.e., maize, bean, and pigeonpea, yet with reduced shading of the legumes by maize. Although still ranked the second most preferred overall, farmers deemed the mbili-mbili system as the most labor intensive as a result of the time taken during planting and care required when weeding the three crops.

Table 12. Averaged technology rankings by the six farmers during 2018 in Babati (note; low number indicates higher preference except for labor where this indicates the most labor intensive).

Technology	Yield	Profitability	Labor needs	Food security	Overall preference
Maize (50 cm) - pigeonpea - topped	2.5	3.3	2.3	2.3	2.5
Maize (513) - pigeonpea	6.0	5.2	5.2	5.3	4.7
Maize pigeonpea - topped	3.5	4.2	3.7	4.8	5.5
Maize–maize-bean - pigeonpea (mbili-mbili)	2.8	2.7	1.2	2.0	3.0
Maize - no Legume	3.8	3.2	6.7	5.0	4.2
Maize–Pigeonpea	3.5	3.7	4.7	4.3	3.2
Pigeonpea - common bean	5.7	5.7	3.3	3.5	4.8

Evaluating ratooning of pigeonpea in intercropping systems

This is an ongoing maize–pigeonpea ratooning trial established at Msekera Research Station in Eastern Province of Zambia and aimed at identifying a strategy for managing pigeonpea in intercropping systems. Highest maize yields were found in the full rotation treatment and lowest yields in the full pigeonpea growth treatment (Fig. 10 - left). All other treatments were in between. Ratooning at maize harvest; or uprooting at maize harvest and reseeding at maize planting; or ratooning again 2 weeks after maize planting seemed to be the best compromise for both maize and pigeonpea grain yield. Delaying the ratooning by 3 weeks after maize planting had negative effects on maize grain yield and pigeonpea grain yield. In other words, delaying the ratooning after maize planting was very beneficial to the maize grain (increased nitrogen from pigeonpea green leaves provide additional boost to maize productivity) but not for the pigeonpea grain (Fig. 5-left).

Biomass production was highest where ratooning and seeding of both maize and pigeonpea was delayed (Fig. 5-right). The lowest biomass yield was achieved in sole maize treatment and maize in rotation with pigeonpea or where pigeonpea was not ratooned at all. Nevertheless, if the pigeonpea biomass of the full growth pigeonpea is harvested (Treatment 3), this will increase the biomass in the full growth pigeonpea treatment. Overall, it is too early to give a consolidated answer on what pigeonpea strategy is the most beneficial for farmers. However, ratooning seems to be an efficient strategy to keep the pigeonpea growing without compromising the maize yield too much. Pest pressure was visually observed during the trial implementation as we wanted to find out if there was any increase in pest incidence due to ratooning. This was particularly relevant in respect to the emerging new pest Fall Armyworm. However, we did not observe any measurable increase of any pest or disease in these trials in response to ratooning or replanting.

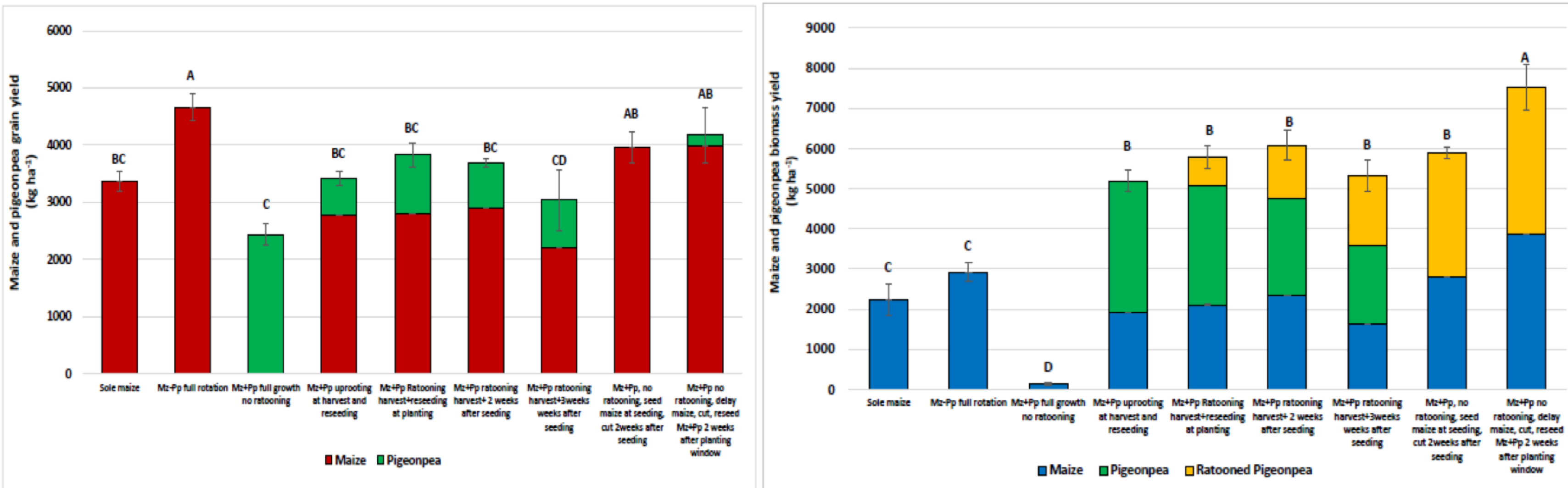

Figure 5. Combined maize and pigeonpea grain yield (left) and biomass (right) (in kg/ha), from a pigeonpea ratooning trial at Msekera Research Station, Zambia, 2017/2018. Error bars represent SEDs; means followed by the same letter in column are not significantly different at P < 0.05 probability level.

Green manure cover crops

i. Maize–pigeonpea systems

Out of 24 on-farm trials, 21 were successfully established and 17 completely harvested with all crops so that a combined analysis was possible. The remaining trials could not be established as the moisture was not enough. The trials show no difference between the maize sole cropping, and all other intercropping strategies except the Maize–lablab treatment (Fig. 6). This suggests that there is no longer a yield penalty for growing pigeonpea with maize after the third cropping season. Growing maize with lablab reduced the maize grain yield by 464 kg/ha, a yield penalty of 22%. The best performing legume grain yield was achieved in the maize–pigeonpea intercropping with cowpea although the grain yields were generally low (Fig. 6-left).

However, although the grain yield of legumes was compromised, the biomass yield was still considerably high especially for pigeonpea treatments (Fig. 6-right). A total of 301 kg/ha of legume grain from the pigeonpea/cowpea intercropping could be added to the maize yield (Fig. 6 -right) thus equalizing the yield penalty from the intercropping. Indeed, combined grain and biomass yield of maize and legumes showed no change in trend compared to the combined grain yield but a huge increase in combined biomass on all other treatments (Fig. 7) with pigeonpea adding a large amount of extra biomass input into the system as compared to growing maize as sole crop. This strategy provides future benefits and has implications for soil fertility if the system is to be planted continuously.

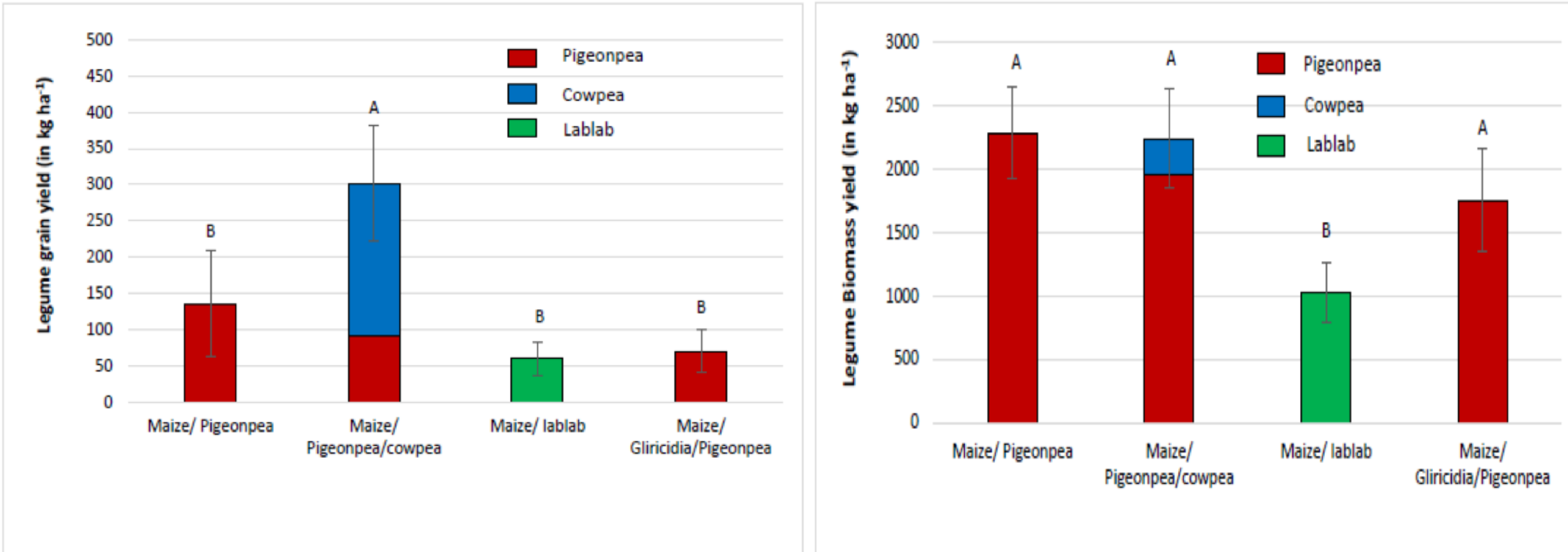

Figure 6. Effect of intercropping on legume grain yield (left) and biomass (right) in on-farm sites (n = 17), Eastern Zambia, 2017/2018. Error bars represent SEDs; means followed by the same letter in column are not significantly different at P < 0.05 probability level.

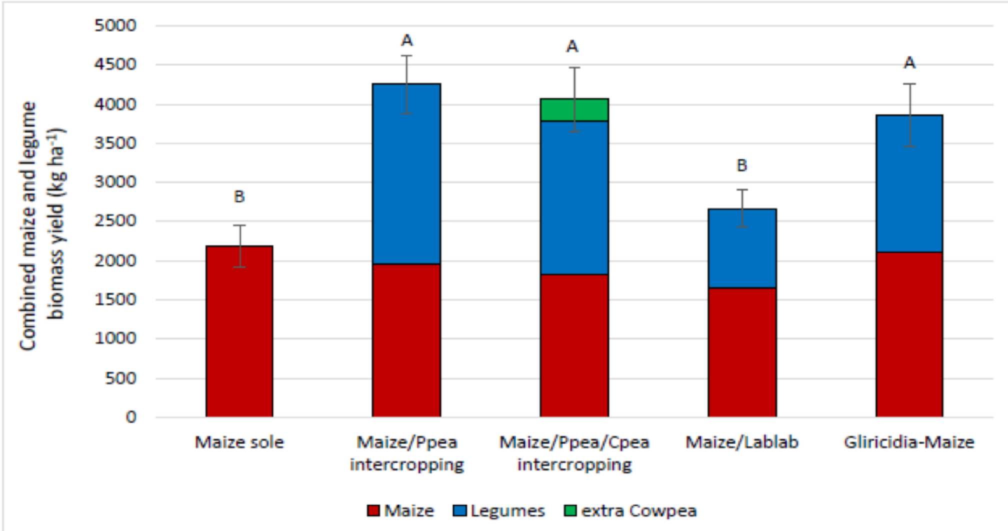

Figure 7. Combined maize and legume biomass yield (n = 17), Eastern Zambia, 2017/2018. Error bars represent SEDs; means followed by the same letter in column are nor significantly different at $P < 0.05$ probability level.

ii. Evaluating and packaging maize-lablab systems

Maize–lablab systems were evaluated both on-station at Msekera, Eastern Province of Zambia, and in 21 successfully established on-farm trials. Lablab yields were generally lower than the pigeonpea/maize intercropping although the biomass yield that developed during April/May was considerable (Fig. 6 - right).

The on-station trial that also evaluated lablab seeded at different times had the following results: In the unfertilized planting area, there was no difference in grain yield amongst all the treatments (Fig. 8 - left). However, in the fertilized area there were a range of different treatments. Both sole legumes in rotation with maize from the previous year had lower grain yields. The lablab intercropping treatment planted at the same time with the maize was second lowest and the highest treatment was the maize intercropped with cowpea. Combined biomass yield of both maize and legume showed significant results in both the fertilized and unfertilized areas. In the fertilized part, maize/pigeonpea and sole lablab had close to 7 t/ha biomass yield and were the highest. They were followed by all maize/lablab intercropping treatments. Lowest was sole maize, sole cowpea, and maize/cowpea intercropping (Fig. 8 - right). Cowpea biomass yield was in general low as by the time of harvesting most of it had already decomposed. In the unfertilized area, maize/pigeonpea was highest followed by lablab and maize lablab intercropping after 7 days, then lablab intercropping after 0 and 21 days. Finally, maize sole cropping, and the two cowpea treatments were lowest. It can be concluded from this trial that despite the adverse cropping season, there were significant benefits of growing maize with intercrops. Different systems clearly show an increase in residual benefits of intercropping pigeonpea and cowpea with maize without suffering maize yield loss.

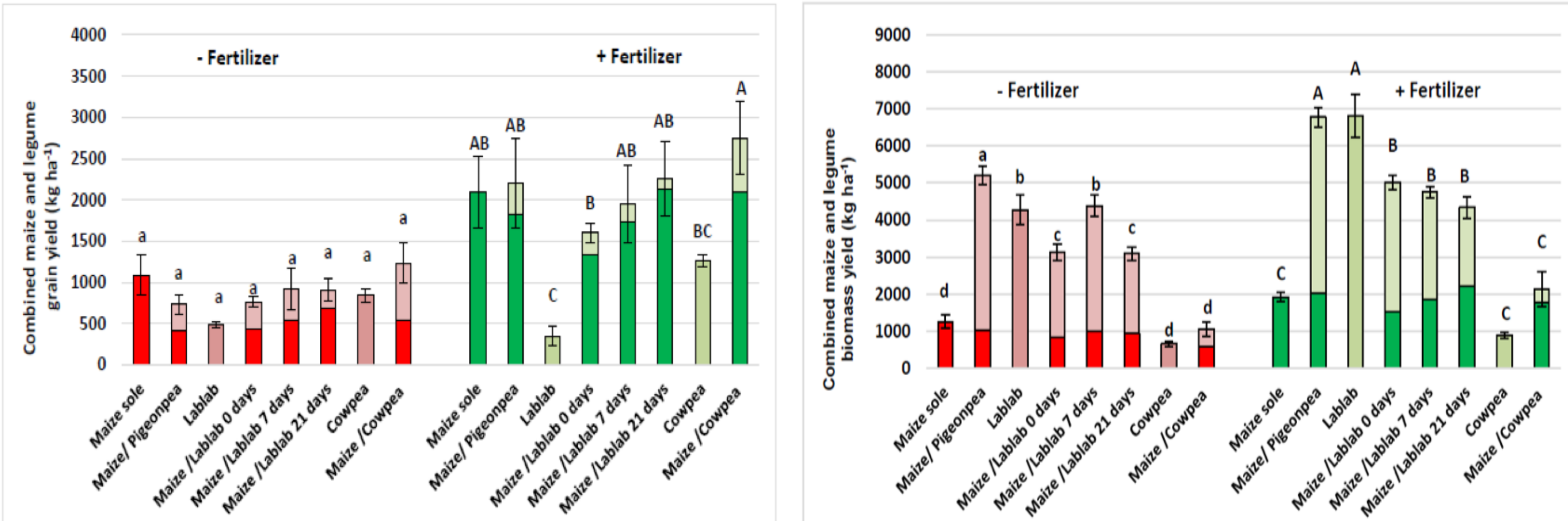

Figure 8. The effect of different intercropping and rotation strategies on combined maize and legume grain yield (left) and biomass yield (right) at Msekera Research Station, 2017/2018; Error bars represent SEDs. Error bars represent SEDs; means followed by the same letter in column are not significantly different at P < 0.05 probability level.

iii. Gliricidia intercropping strategies

One on-station trial was continued at Msekera Research Station in its Year 3, with revised treatments to include a) full maize–groundnut rotation; b) maize/*Gliricidia* (intensive spacing)—groundnut rotation; c) maize/*Gliricidia* (dispersed spacing)—doubled-up legume system rotation. The results to date show no significant difference between any treatments which is a positive outcome. *Gliricidia* intercropping did not lead to a yield penalty for both maize and combined legume yields. However, there was also no yield benefit (yet) from the *Gliricidia*, as expected. The reasons for lack of productivity in the maize is likely due to the amount of *Gliricidia* leaves that are applied (i.e., the trees are still small) and the relatively high fertility situation at the site of trial. All replicates receive a half rate of mineral fertilizer as well that might mask the organic fertilizer effect of *Gliricidia* leaves. To date the results are not conclusive and the study will have to be continued.

Integrating livestock into cropping systems

Home-made rations for poultry

A study was conducted to assess the performance of supplementation with homemade feed rations for local chickens under improved housing in rural areas of Babati District. Formulated rations improved growth rate by 53% more than scavenging chickens of 20 weeks of age. Partially housed local chickens with formulated rations and limited scavenging gained 253 g (29%) over the fully outdoor scavenging chickens at the age of 20 weeks (Fig. 9). Improved feeding required a concurrent supply of medicinal packages to reduce mortality rates (Fig. 10).

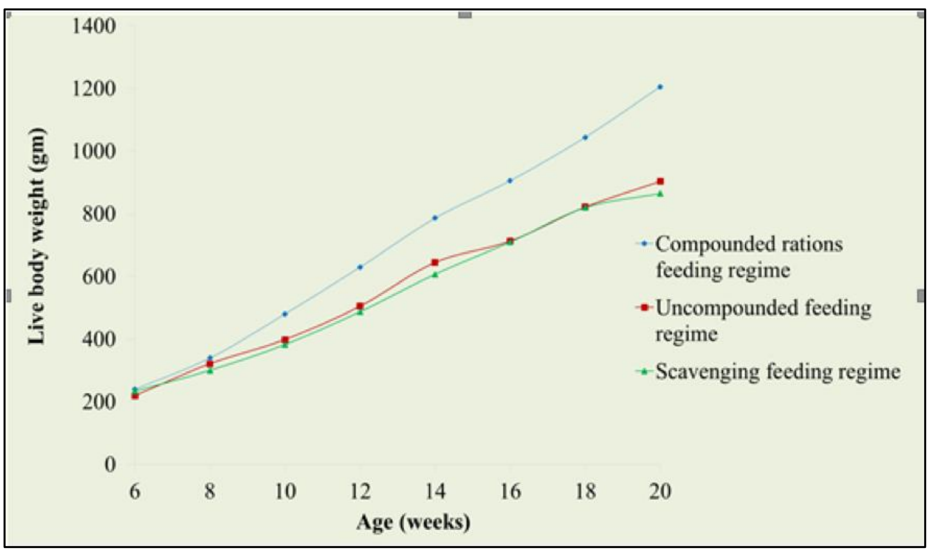

Figure 9. The influence of feeding regime on live body weight.

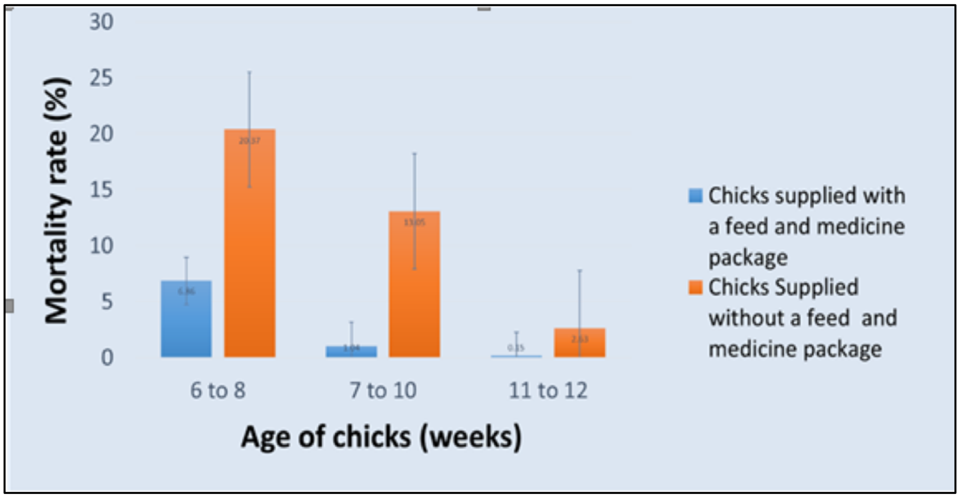

Figure 10. Bundled delivery of inputs (feeds and medicines) improves survival of chickens at their different stages of growth.

Cost–benefit analyses of the improved forage technologies

This study conducted interviews at household level (n = 191, 24% female) in 14 villages of Babati and group discussions at village level. Data are being analyzed.

Feeding and housing for goats

In Malawi, on-station goat feeding trials conducted at LUANAR were completed. Data suggests that goats gain weight faster when fed on a supplementary diet that includes both Faidherbia and Gliricidia (Table 13). The supplementary feeding material is widely available in the study sites. The weight gains due to feeding over a 60-day period improved net income (Fig. 11).

Table 13. Weight gain for goats given supplementary feed with Faidherbia pods, Gliricidia leaves, or Gliricidia + Faidherbia over a 60-day period.

Treatment/Diet	Change in weight (kg)	Growth rate (kg/day)	Daily growth rate (g/day)	Value of weight gain (USD)	Profit (USD)
Faidherbia	6.28	0.10	104.58	15.69	14
Glirircidia	5.64	0.09	93.96	14.09	12
Gliricidia + Faidherbia	7.33	0.12	122.08	18.31	16
Grazing only	3.78	0.06	62.92	9.44	9

Note: Cost of collecting feed from the ecosystem is assumed 1 USD/month/goat.

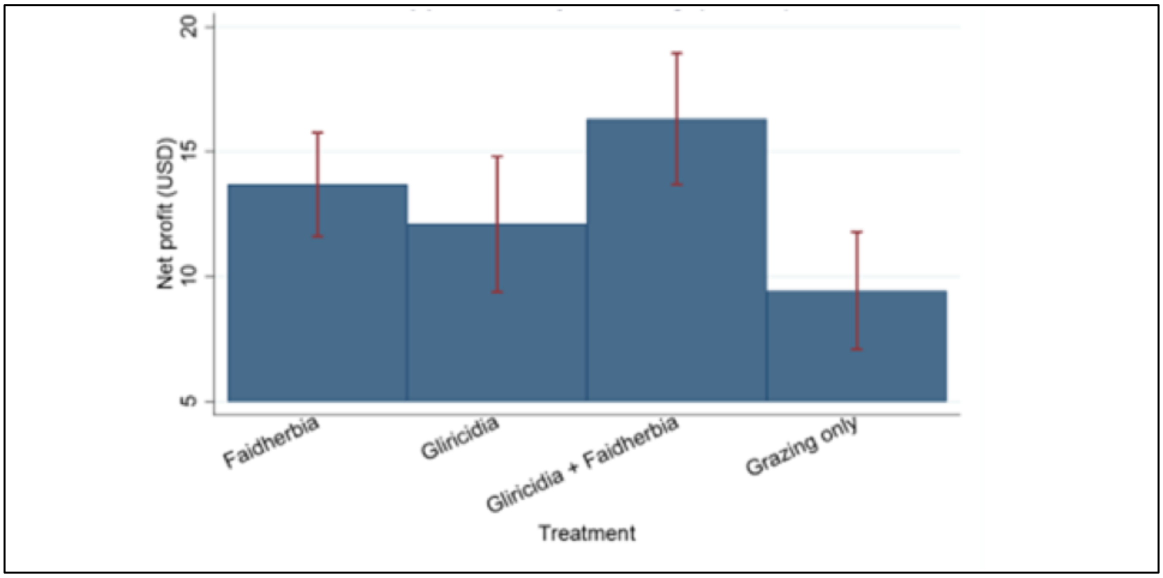

Figure 11. Net profit based on grazing only or on supplementary feeding of goats with *Faidherbia, Gliricidia*, or *Gliricidia* + *Faidherbia* pods. Net profit was highest with supplementary feeding that had a combination of *Gliricidia* leaves and *Faidherbia* pods.

Outcome 2. Natural resource integrity and resilience to climate change enhanced for the target communities and agroecologies

Land use suitability mapping

A journal article has been submitted for peer review. The manuscript presents results on mapping long-term, spatial-temporal trends in rainfall to identify locations experiencing less or more rainfall. The mapped trends identify changes in agricultural potential due to climate change and therefore the results are useful in guiding spatial targeting of appropriate climate-smart agricultural technologies. The study covers seven countries (Tanzania, Zambia, Malawi, Kenya, Uganda, Burundi, and Rwanda) and will contribute to mapping regional relevance of Africa RISING technologies. Results were presented and published in proceeding of the European Geophysical Union (EGU) http://adsabs.harvard.edu/abs/2018EGUGA..20.4628M

Climate-smart land management technologies

Long-term effects of in situ water harvesting

A study involving four farmers who have installed tied ridges in the 2015/2016 and 2016/2017 cropping seasons was used. New (annual tied ridges) were also installed by new participating farmers. Each participating farmer was treated as a replication. The sorghum grain yields varied from 1037 kg/ha under conventional tillage without fertilizer to 1445 kg/ha for annual tied ridging with the application of 20 kg of P/ha (Table 13). Yields of crops grown under conventional tillage and in-situ rainwater harvesting technologies with and without fertilizers were significantly different ($P > 0.05$).

Table 13. Effect of *in-situ* rainwater harvesting technologies and fertilizer application on sorghum grain yield at Laikala village during the 2017/2018 cropping season.

Tillage Method	Sorghum grain yield, kg/ha	
	0	20 kg of P/ha
Conventional tillage	1037	1155
Residual tied ridging	1173	1248
Annual tied ridging	1279	1445
CV	24.4	
F Value	0.71	

*CV = Coefficient of variation.

Residual tied ridge on maize Sagara village, Kongwa

Twenty farmers were engaged to explore the effects of residual tied ridges on maize yields. These farmers used fields that had been previously installed with tied ridges. The test crop was Meru HB513, an improved maize hybrid. ANOVA showed that both tillage methods had no significant ($P > 0.05$) effect on maize grain yield. However, conventional tillage in plots installed with terraces (CTT) increased maize grain yield by 24.1% and at the same time use of residual tied ridges (tied ridges constructed in two seasons ago) increased maize grain yield by 30.8% over conventional tillage practice. The results indicated that maize grain yield ranged from 2,583 kg/ha under conventional tillage (CT) to 3,379 kg/ha for residual tied ridging during the 2018 cropping season (Table 14).

Table 14. Maize grain yield (kg) as affected by tillage techniques in 2017/2018 cropping season during the 2017/2018 cropping season in Sagara village, Kongwa District Council.

Tillage method	Kg/ha	Yield increment, %
CT	2583	–
CTT	3206	24.1
RTR	3379	30.8
*CT = Conventional tillage; CTT = conventional tillage under Fanya juu/chini terraces; RTR = Residual tied ridging		

Opportunities for enhancing water resource use through irrigation

Within the Gallapo and Seloto villages of Babati District, Africa RISING successfully rolled out 16 on-farm trials of two irrigated vegetable varieties (green pepper and tomato) as planned in a follow-up season. Vegetable productivity (fresh vegetable weight as sold on market) and specific environmental variables (soil moisture and microclimate) are currently being measured. The human and social domains were also captured during this project cycle. The dataset was mainly focusing on the three domains of the sustainable intensification assessment framework (Productivity, Economic, and Environment). In addition, Human and Social elements were collected in relation to roles, preferences, and access to resources.

The data is characterized by biophysical components mainly on water use trends inside and outside the screen house through a drip irrigation system. The experiment had automated microclimatic measurements for assessing evapotranspiration. Combined with the amount of water applied, this permitted the computation of water use efficiency. This is complemented with data on the economics of vegetable production, which is a combination of marketable yield and prevailing prices at the time.

Farmers also highlighted their preferences comparing drip irrigation vs conventional bucket irrigation, the labor associated with each technology was also assessed. This permitted us to explore the human and social elements of the work that was being conducted. This work was a joint effort as 'loose ends' between CIAT and the World Vegetable Center. The final analysis of data will be completed and shared by end of November.

Doubled-up legume as an associate technology to Conservation Agriculture (CA)

In the Eastern Province of Zambia, five doubled-up legume trials (both maize and legume phase) were established (December 2017) and harvested in April/May and August 2018 (pigeonpea). The best performing treatment was the groundnut in combination with half the pigeonpea under conventional agriculture, followed by the combination with full groundnut and full pigeonpea in both cropping systems (Fig. 12). Different to previous years, both sole planted legumes were outperformed by the combinations which proves the concept that planting legumes in a doubled-up system will give overall more grain yield benefits, especially under drought. The maize phase planted across the legume trials from last year did not reveal any significant benefit in cropping systems or between treatments. This is somehow different from previous seasons where the maize planted after doubled-up legumes under CA outperformed the maize planted after doubled-up legumes under conventional tillage. The reason why legumes performed differently than in previous years can be attributed to the adverse rainfall distribution in some of the sites, which led to a long dry spell in the first part of the cropping season (December to January 2018) in most trial areas (except Hoya). This negatively affected the groundnut (unlike in cropping season 2016/2017) while the pigeonpea yield was not affected due to its drought-resistant characteristics. This also means that a strategic combination of both crops is a sensible risk mitigation strategy. Surprisingly little residual effect of legume combinations was observed on the maize yield in this cropping season, which we are yet to understand.

It is proposed that a combination of groundnut with half pigeonpea is the best performing legume system in a doubled-up legume trial. If this can be planted under CA without making ridges, this will lead to additional financial benefits as the labor for land preparation can be reduced. A gross margin analysis of the data is still required to understand the financial implications of all strategies.

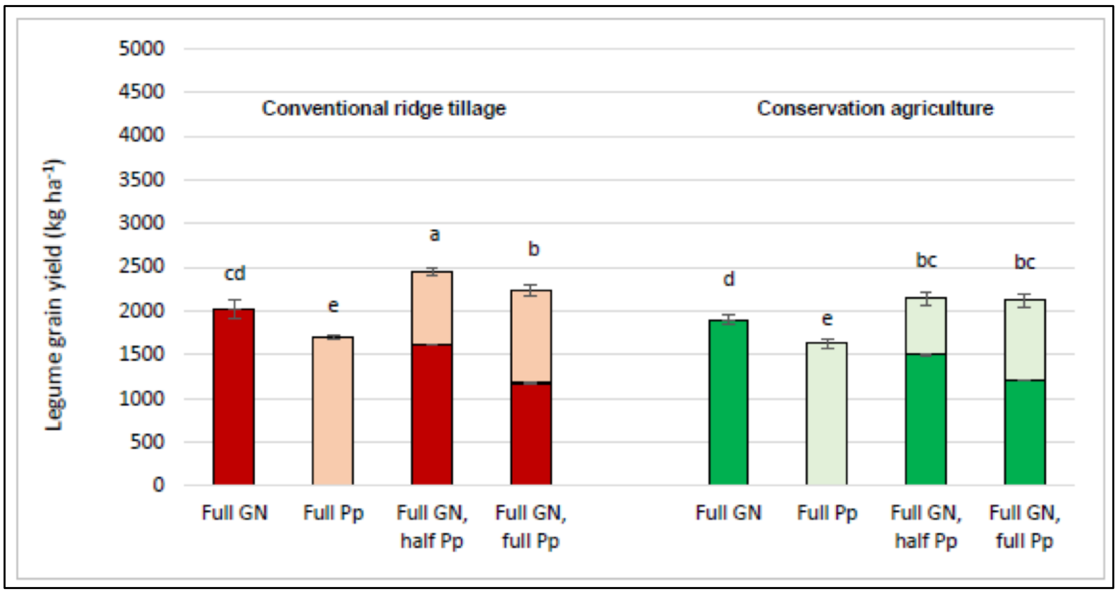

Figure 12. Groundnut (GN) and pigeonpea (Pp) yield planted in a doubled-up legume trial under conventional ridge tillage and conservation agriculture in 5 agriculture camps of Eastern Zambia, 2017/2018. Error bars represent SEDs; means followed by the same letter in column are not significantly different at $P < 0.05$ probability level.

Understanding water infiltration rates in different farm systems

In Babati, soil water infiltration tests were carried out at field level using minidisk infiltrometers at two suctions i.e., -2 cmsec^{-2} (i.e., through macropores of about 1.45 mm diameter) and -6 cmsec^{-2} (i.e., through micropores of about 0.48 mm diameter). Results from the analysis showed the infiltration rates through the macropores ranged from 1.1 to 0.45 mm/sec^2 across the eight farms assessed (Table 15). Similarly, infiltration through the micropores ranged from 0.04 to 0.01 mm/sec^2. The high infiltration rate at the field of Farmer 8, a desirable attribute, can be attributed to high organic matter (field located in a depositional site and a homefield). Application of residue and/or manure are important in this process. On the other hand, Farmer 1’s field is characterized by a clay loam soil often associated with poor infiltration. To address the impaired infiltration experienced in this field, it is advisable to apply organic resources, which could help to improve soil structure and increase soil pore volume. A similar recommendation would apply to fields having reduced water infiltration rates in all the four villages.

Table 15. Effects of farm management on soil water infiltration rates in eight farmer fields of Babati, Tanzania, during the 2018 cropping season.

Farmer ID	2 cm/sec^2 suction	6 cm/sec^2 suction
Farmer 1	0.45a	0.01a
Farmer 2	0.47a	0.012ab
Farmer 3	0.69a	0.013abc
Farmer 4	0.77a	0.014abc
Farmer 5	0.9a	0.015abc
Farmer 6	0.49a	0.021bc
Farmer 7	0.78a	0.024c
Farmer 8	1.1a	0.04d

Note: Means followed by the same letter in column are not significantly different at P < 0.05 probability level.

Use of locally available organic nutrient resources and fertilizer

Pathways for efficient resource and carbon transfers within and between farms

In this study, it was hypothesised that resource transfers are driven by livestock ownership as well as ownership of land and farm implements (tractors, ox-carts, and ploughs). Drivers of organic resource transfers, i.e., from one farmer to another, observed in Babati include the need for extra income, exchange for labor, and the distance of off-fields from the homestead. Using regression trees, it was observed that inclusion of either livestock or land/farm implement variables (numeric) had the greatest effect on resource flow regression trees with partitions at < 15, 15–53 and >53 units for land/farm implements ownership and < 1.6, 1.6–6.1, 6.1–14 and > 14 units for livestock ownership. These classes were used to develop a matrix of resource flows (Table 16). Using Kruskal-Wallis tests, both livestock and land/farm implement ownership highly influence resource flows ($P < 0.01$). Separation of means using t-tests show significantly lower resource scores for the farmers under the low land/farm implement ownership category than other farmers. Similar results regarding differences are obtained when both manure and crop residue exchanges are assigned similar weights, except for a significant difference ($P < 0.05$) also between medium and high land/farmer implement ownership. Resource flow scores increase with livestock ownership and farmers with very low livestock numbers (< 1.6 units for livestock ownership), are net exporters of organic resources. Overall also, increased ownership of land and farm implements is associated with increasing organic resource importation.

Table 16. Resource flow scores under different farmer classes of livestock ownership and other wealth in Babati as observed in 2017.

Livestock ownership	Land/farm implement ownership			
	Low	Medium	High	Mean
Very low	0.93	1.07	0.75	0.96^a
Low	1.00	1.41	1.20	1.30^b
Medium	–	1.66	1.82	1.78^c
High	–	–	1.98	1.98^c
Mean	0.94^a	1.36^b	1.61^b	–

Note: Means followed by the same letter in column are not significantly different at P < 0.05 probability level.

In the previous reporting on resource transfers, results from recursive partitioning of maize grain yield under the farmers' practice in 2017 were provided. In this reporting, results from the analysis of maize yield under improved practice in 2017 is discussed. Consistent with maize yield increase after manure application in farmer fields, similar results were observed in improved practice. Similarly, with the regression trees, manure application was the critical factor determining maize yield increment hence the first node of the trees with 1 t/ha more grain yield compared to farmer fields without manure. Failure to apply manure in improved practice led to a reduction of maize grain yield by 1.4 t/ha in the strong and moderate slopes compared to fields on gentle and very gentle terrain (Fig. 13). In addition, feeding animals in the fields results in another 0.9 t/ha additional yield. With manure application, only the frequency of application influenced yields under the improved practice.

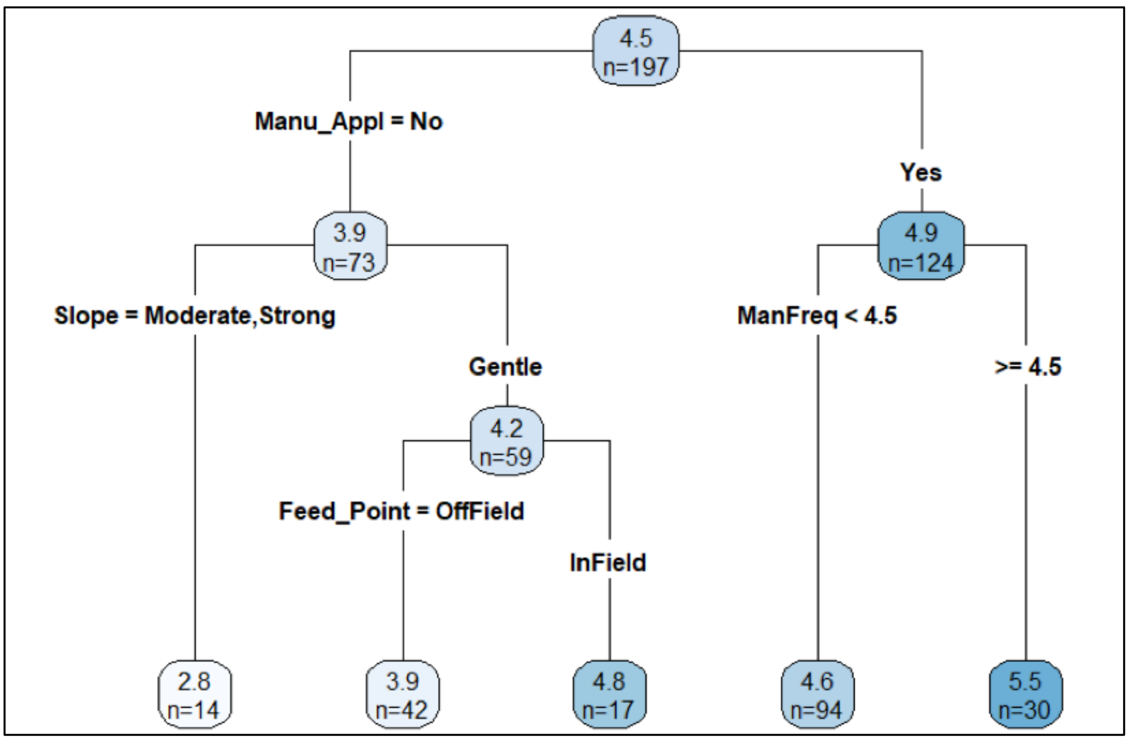

Figure 13. Recursive partitioning of maize grain yield under improved practice (20 kg P/ha plus 50 kg N/ha and planting at appropriate densities) in 2017. P values are based on Welch's test undertaken independently at each of the nodes based on the splitting variable.

Similar to the farmer practices, the variability in total carbon in the improved practices is controlled by the slope position (Fig. 14). However, feeding point is the most important factor with fields where residues are not taken away (infields) having lower carbon than those where residues are removed. This is interesting since in-field feeding resulted in more yield than off-field feeding indicating that in-field feeding could be a deliberate strategy of farmers to improve fertility of poorer fields.

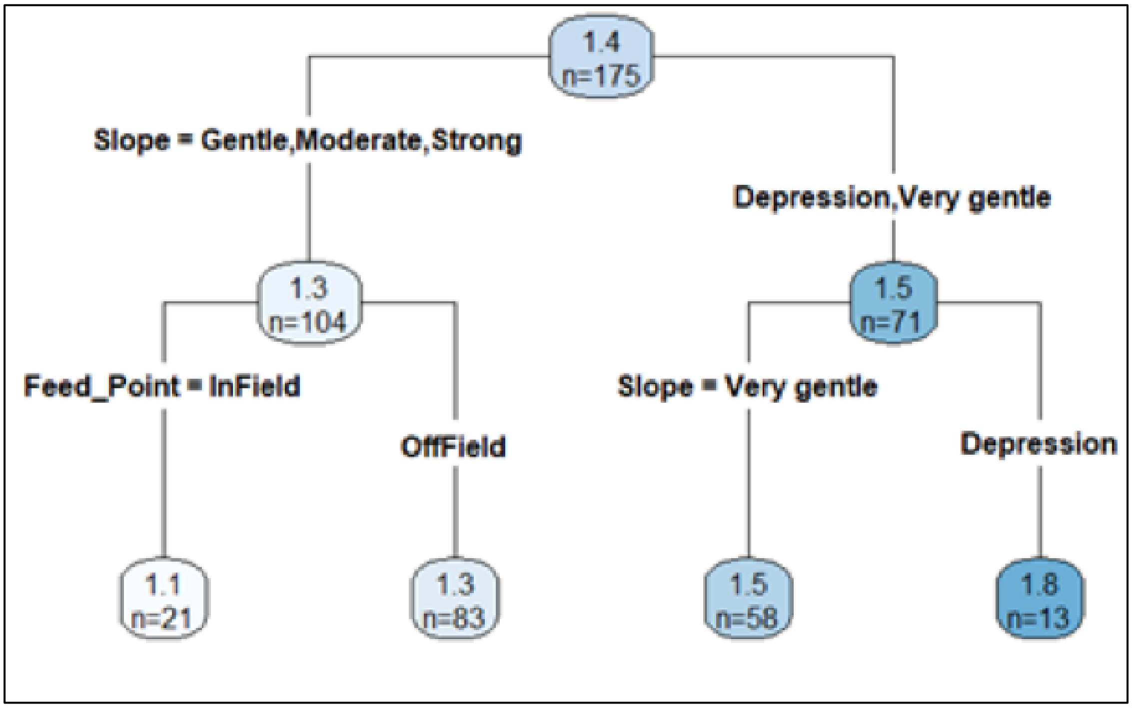

Figure 14. Recursive partitioning of soil total carbon under the improved practice as observed in Babati, northern Tanzania in 2017. P values are based on Welch's test undertaken independently at each of the nodes.

Fixed or rainfall-responsive nitrogen fertilization strategies

In Malawi, Machinga District, six on-farm experiments were established in Ntubwi, Nsanama, and Nyambi EPAs to assess the effects of N fertilization strategies on maize productivity and N use efficiencies under rain-fed conditions across a rainfall gradient spanning over three agroecologies. The experiment consisted of nine treatments: eight treatments based on fixed-N application strategies to a maximum of 92 kg/ha and one variable N application strategy, hinged on the quality of the rainfall season. All plots received 10 kg/ha P as single super phosphate. Soil moisture in two low and two high N treatments was monitored using moisture probes.

Across sites, maize grain yields increased from 0.9 mg/ha for P only treatment to a maximum of 3.5 mg/ha when 92 kg/ha N was applied (Fig. 15). Due to an extended dry spell, a maximum of only 46 kg N was applied for the variable N treatment, achieving yields of 3.2 mg/ha. The N response strategy does not necessarily result in largest yields but increases N-use efficiency substantially. This is essential for improved economic gains with use of expensive N fertilizer resources.

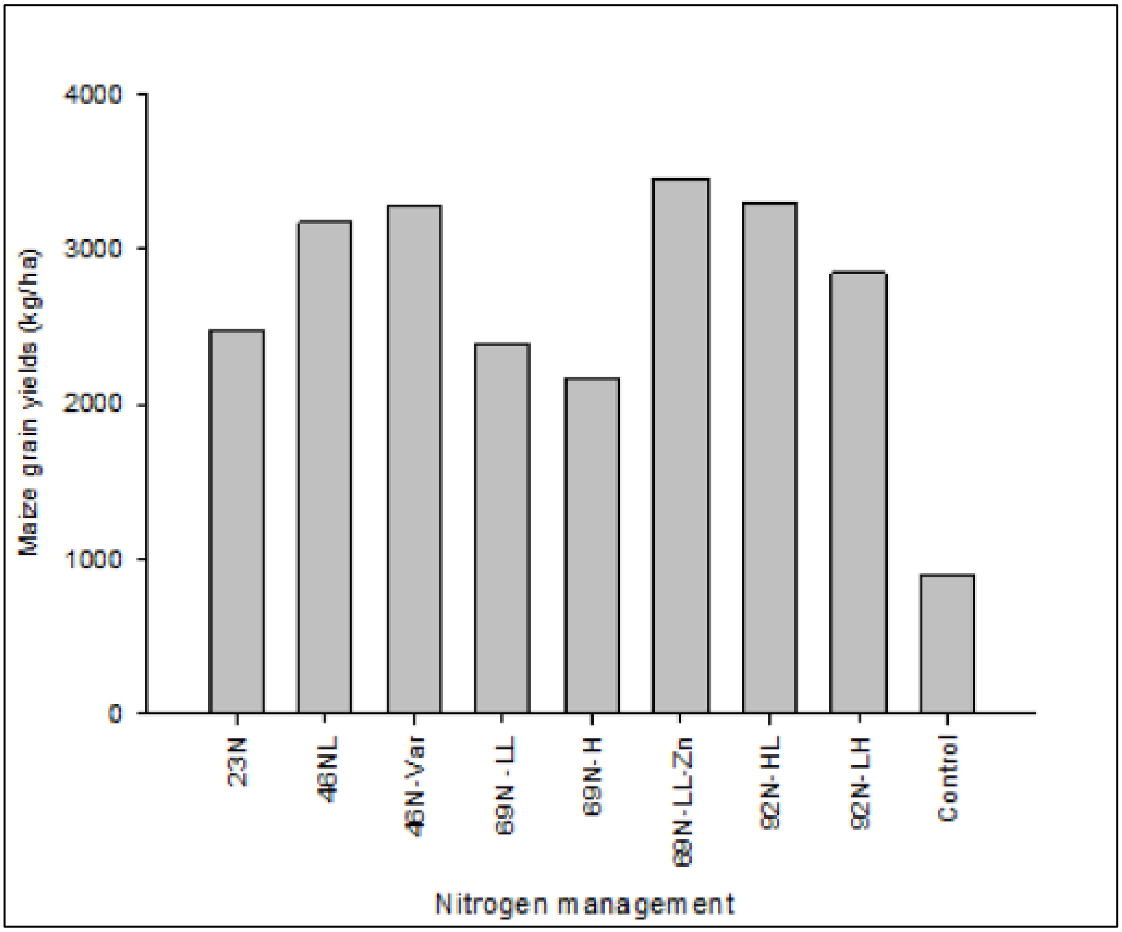

Figure 15. Response of maize to different nitrogen management strategies in southern Malawi. Protocol for treatments is given in Table 17.

Table 17. Protocol for N response experiments in Malawi. Source: September 2017–March 2018 Report.

Treatment	Basal NP	N top dressing as amm nitrate	Basal N and P	Side dress 1 (4WAE)	Side dress 2 (6 WAE)	Side dress 3 (8-9 WAE)	Total
1	Control -P only as SSP	0	0:21				0
2	NP (23:21)	0	23:21				23
3	NP (23:21)	+23 N	23:21	23			46
4	NP (23:21)	+46 N	23:21	23	23		69
5	NP (23:21)	+69 N	23:21	23	46		92
6	NP (23:21)	+92 N	23:21	46	46		115
7	NP (23:21)	+115 N	23:21	46	46	23	138
8	NP (23:21) + Micronutrients	+69 N	23:21	23	46		92
9	NP (23:21)	Variable N	23:21	var	var	Var	var

Outcome 3. Food and feed safety, nutritional quality, and income security of target smallholder families improved equitably (within households)

Improving nutrition of children under 3 years

Promoting inclusion of nutrient-rich research products in children's diets

These studies were conducted in Mlali, Laikala and Moleti villages of Kongwa District in Tanzania, underpinned by consumption of diversified and aflatoxin-free nutritious foods made from nutrient-dense legumes, vegetables, and cereals, between August to December 2017. Anthropometric measurements were done monthly for the feeding duration until May 2018. Results show that there was a decrease in wasting in Laikala and Moleti villages (approximately 3% and 2%); and child wasting decreased by 2 and 1% in Mlali and Laikala villages, respectively. However, stunting, an indicator of chronic malnutrition, almost doubled in all 3 villages after the feeding period (Fig. 16), an indication of weak technology adoption. This was despite engaging mothers in the production of home garden vegetables during the dry season (Fig. 17) to maintain vegetable supply over the year. Further investigation on such observations will be crucial to ensure adoption of interventions.

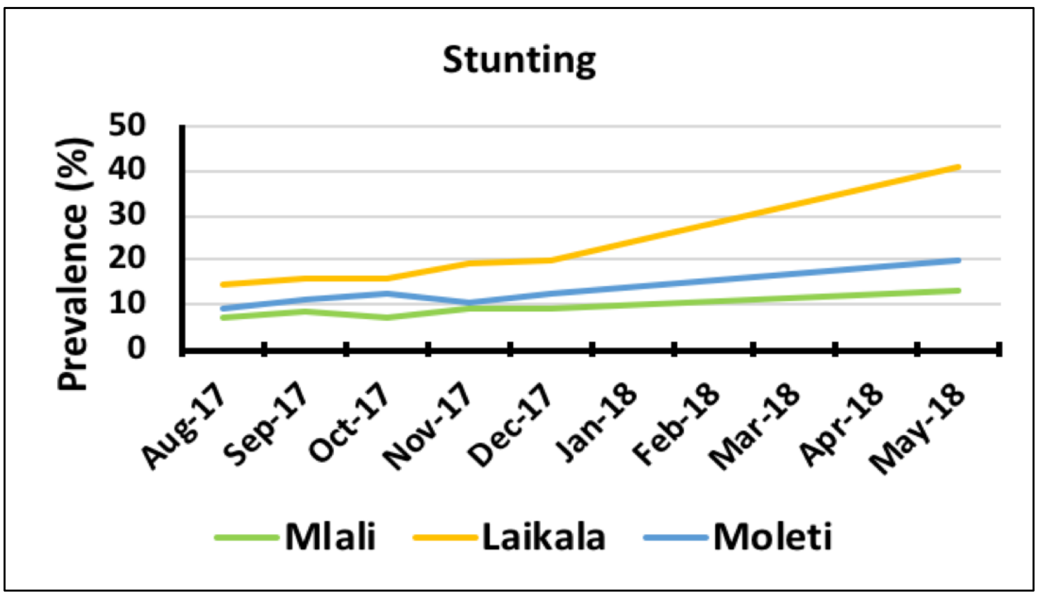

Figure 16. Prevalence of stunting in children fed on formulated complementary food.

Figure 17. Mothers in Mlali, Kongwa District showing their happiness after harvesting vegetables in the sack gardens. Photo credit: Yasinta Muzanila/ Sokoine University of Agriculture.

Packaging and delivery of postharvest technologies

Characterization of the mycotoxin spectrum across two agroecologies in Babati District
Maize samples were collected before and during storage (July 2017– March 2018) from two agroecologically different trial locations: Long village (S4°13'15.62''; E35°25'31.80''; 2162.8 ma sl) and Seloto village (S4°15'2.48''; E35°31'3.70''; 1628 masl) in Babati District of Manyara Region. The agroclimatic conditions of the two villages represent the high and midaltitude northern highlands of Tanzania. Long village was cooler than Seloto by about 3–4°C and more humid by 4–11% rh points during the sample collection period. Maize variety PAN 691, a flint long maturing hybrid suitable for the high-altitude regions, was grown in Long while variety SC 627, a semi-flint medium maturity hybrid with drought-tolerant properties, was grown in Seloto. A full mycotoxin spectrum screening of the grains was performed using liquid chromatography tandem mass spectrometry LC-MS-MS as detailed by Malachova et al. (2015[1]). Results showed overall incidence of 0.6% for aflatoxin implying that the environment in both villages was not suitable for its contamination. Only those mycotoxins that survive the described environment were prevalent (Fig. 18). Generally, there were locational differences in the incidence of individual toxins. With the exception of fumonisin B1 where 3.5% of samples had contamination exceeding 2 mg/kg, toxin levels determined for all major mycotoxins were below the recommended limits in foods. Improved shelling, drying, and hermetic storage decreased fumonisin contamination by 15.6–18%.

[1] Malachova, A., Sulyok, M., Beltran, E., Berthiller, F., Krska, R. (2015). Multi-Toxin Determination in Food—the Power of "Dilute and Shoot" Approaches in LC-MS-MS. LC GC Europe, 28, 542–555.

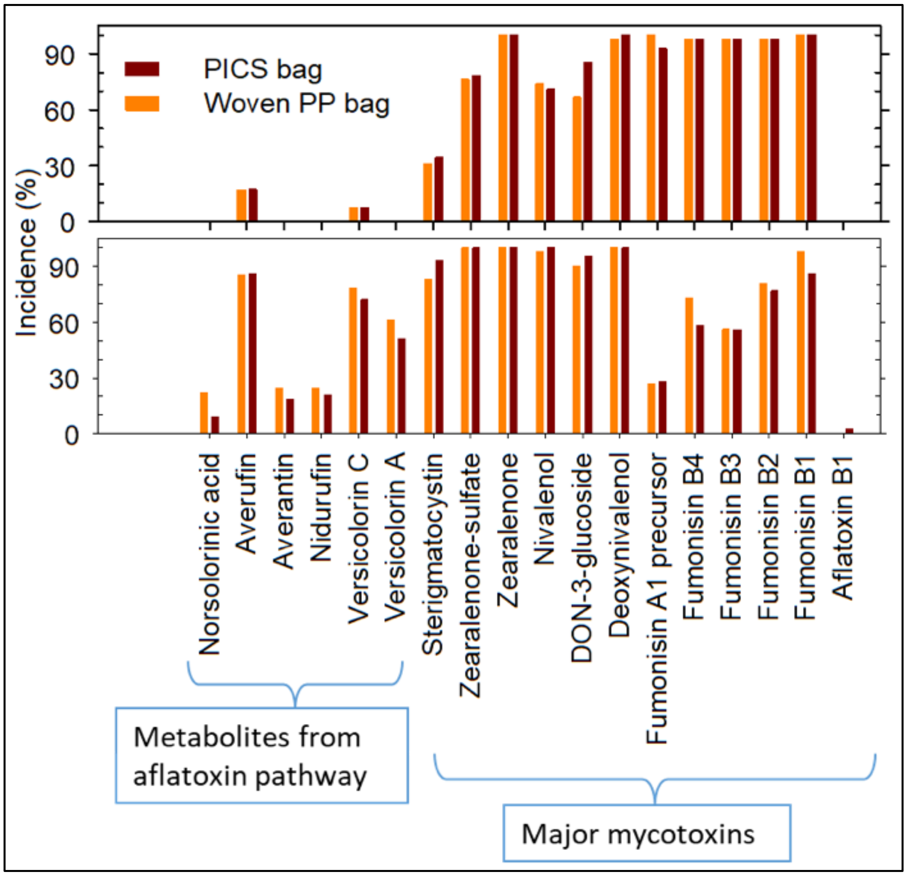

Figure 18. Incidence of major mycotoxins in Seloto (bottom) and Long (top) villages.

Outcome 4. Functionality of input and output markets and other institutions to deliver demand-driven sustainable intensification research products improved

Deploying mechanisms that inform farmers about dynamic market needs

Exploring ICTs for linking farmers to markets

Data collected on the continued test implementation of the MWANGA platform in Babati reveals that 85% of the farmers who received the messages (see example, Fig. 19) had found them useful. The text messages were sent through the MWANGA Platform to the targeted audience. The procedure was through a survey instrument, administered over 1 month (waiting period to get responses); the response rate was 83% (sent to 463 members, and received 385 responses). The attrition rate was about 18%. The instrument that was used for this purpose is part of the Africa RISING-NAFAKA Quarterly Report to the USAID Mission in Tanzania (Quarter – April 01 to June 30, 2018).

The smooth delivery of information was obstructed when farmers reported loss of their phones or that they were not able to see the messages in some occasions, sighting that they thought messages were from telemarketers. There has been further development of an android App for the MWANGA platform for sharing agronomic, market, and climate services information with farmers (Fig. 20).

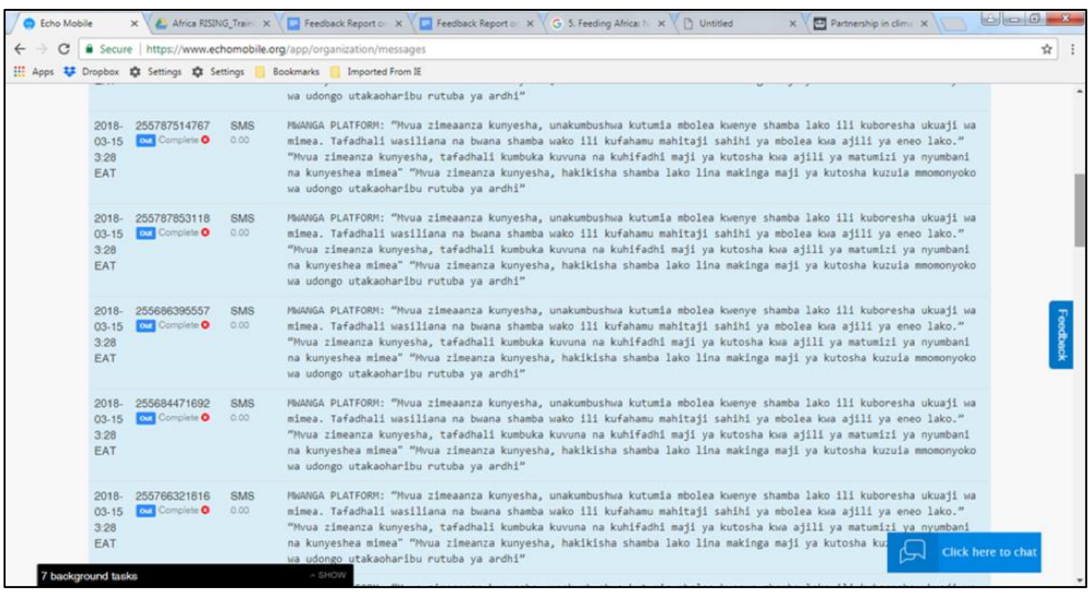

Figure 19. Sample messages shared with farmers on the MWANGA Platform.

Figure 20. App features for the UKULIMAIQ.

Value chain stakeholder mapping

The quest for identifying development institutions for partnership in taking our technologies to scale is also being used to map stakeholders involved in various stages of different value chains. A 19–20 June meeting with livestock holders in Babati District, but consisting of stakeholders from both within and without the district, identified those that are engaged in (a) multiplication and distribution of forage planting materials (9), (b) animal husbandry and breeding (7), (c) animal health (8), (d) feed formulation (5), (e) marketing (5), and (f) provision of loans (1). Different strategies aimed at strengthening collaboration among livestock stakeholders, including farmers, were identified during the meeting.

Outcome 5. Partnerships for the scaling of sustainable intensification research products and innovations

Partnerships for scaling

Livestock

One partnership meeting has already been described under Outcome 4 – Value chain stakeholder mapping section.

Postharvest

Beginning July 2018, Africa RISING consolidated partnership with Iles de Paix (IDP), a Belgian NGO whose mission is to promote sustainable family farming and responsible food systems, by commending partnership activities. Africa RISING will build IDP's capacity and leverage on their approaches for success in taking Africa RISING's postharvest research outputs to scale. In the partnership "Kilimo Endelevu" (Sustainable Farming) program is IDP's implementing arm. The program comprises two local partners: MVIWATA (National Network of Small-Scale Farmer Groups in Tanzania) and RECODA (Research, Community and Organizational Development Associates). Thus, IDP mobilizes farmers in producer organizations (POs) through MVIWATA and identifies their developmental needs through RECODA. Also, RECODA proposes a basket of production options and demonstrates these options to farmers on demo plots. Africa RISING strengthens RECODA's role by providing tested and validated postharvest technologies.

The research and development model for innovation delivery and scaling comprises two components: (a) introduction of the technologies in IDP's action villages using a mother–baby demonstration approach whereby learners (farmers) train their peers in a cascading mode, backstopped by Africa RISING; and (b) joint research activities by Africa RISING and IDP to: (i) address specific farmer type challenges and (ii) build the capacity of IDP's personnel and partners. AR trained 192 farmers and 21 extension staff in eight villages on improved postharvest management practices; installed 34 household storage demos in eight villages; and conducted one survey to evaluate performance constraints with use of motorized shellers by local farmers. What is unique in the partnership is (i) commitment of IDP to support continuous needs identification through research by taking 17.8% of the research cost, (ii) assigning roles to partner institutions to sustain impacts at scale while Africa RISING demonstrates tested technologies and conducts research to support the technologies by aligning them to the needs of users/potential adopters. The current partnership actions sites are given in Figure 21.

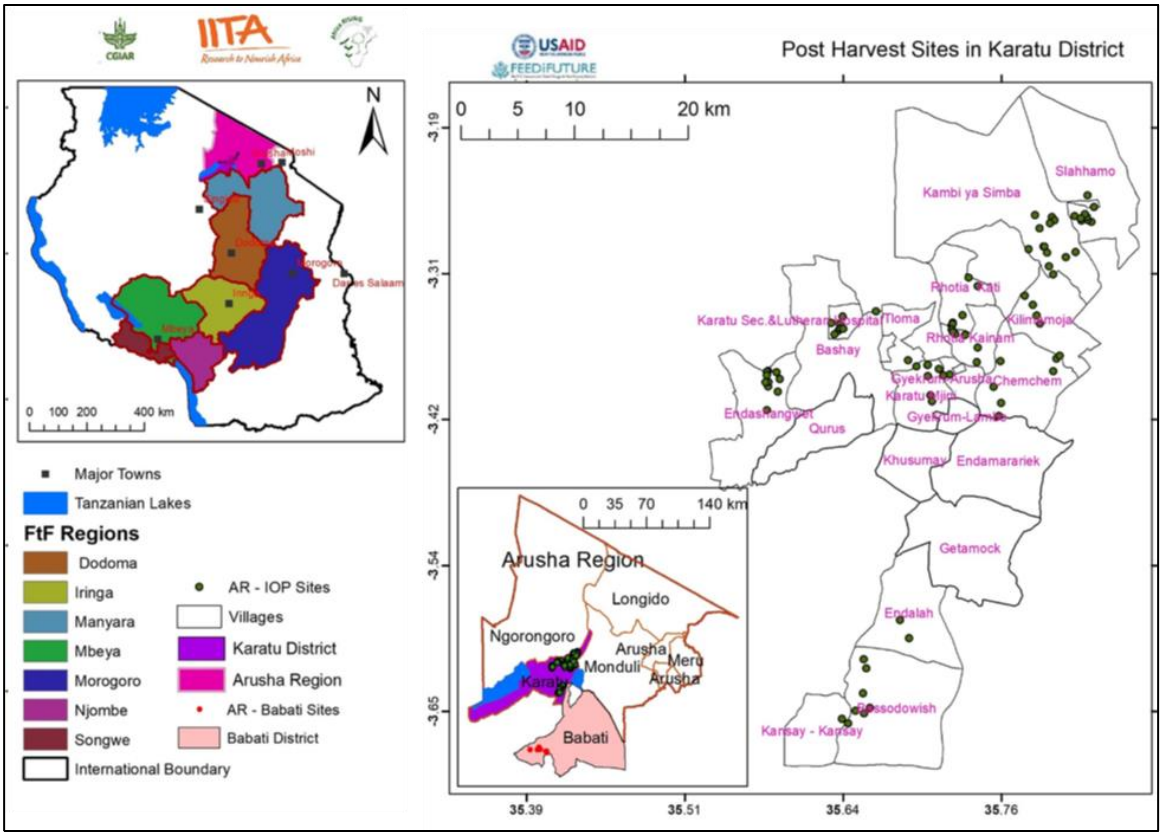

Figure 21. Africa RISING – Iles de Paix action sites (right) in Karatu District.

Vegetables

In the last report was an item on the ongoing, successful collaboration between Africa RISING and Catholic Relief Services. On the 19 September, a meeting was held to plan another collaboration, this time addressing the vegetable component. This was followed by a fact finding mission on 24–25 September to (1) to observe the ongoing vegetable activities in the area (Fig.22), (2) identify knowledge and research gaps, and (3) propose the areas of integration/collaboration. The partnership identified potential areas of collaboration as being:

Production

i. Capacity building through facilitation of various trainings to provide technical support particularly on:
   a) Good agronomic practices **(GAP)** through on-farm research trials demonstrating improved technologies (e.g., use of improved vegetable seed varieties, healthy seedlings etc.)
   b) **IPM** - focus on biological control methods including use of biopesticides (non-poisonous living organisms) and botanical pesticides.

Utilization

i. Nutrition (e.g., capacity building-nutrition messaging (BCC))
ii. Training on preparation of vegetable-based recipes (utilizing the locally available foods)
iii. Postharvest - Train farmers on appropriate vegetable postharvest handling practices/techniques and storage of vegetable seeds.

Support monitoring and evaluation
WorldVeg to support Kilimo Endelevu project monitoring and evaluation.

Refresher trainings for IDP staff
WorldVeg to continue building the capacity of technical staff and extension agents on vegetable production techniques a sthe need arises.

Discussions on a MoU based on the above is being pursued.

Figure 22. Mrs Eutropia Kanso (front and left) asking for advice on how to improve her vegetable nursery at Mbulumbulu ward in Karatu District. Researchers are well placed to address such challenges. Photo credit: Justus Ochieng/WorldVeg.

CA and associated technologies
Africa RISING has intensified its linkages with CRS in Zambia which continues to be a very fruitful partnership that will go beyond the USAID Mission supported activities in the Eastern Province. CRS has already committed some funds (US$37,000) for the 2018/2019 cropping season to continue some of the trials in the next cropping season. AR values CRS engagement in its research activities (Fig. 23) and the advice generated through such engagements. A blog report highlighting the work on GMCCs with CRS in the region was recently published http://www.cimmyt.org/what-is-green-manure-and-how-is-it-helping-maize-farmers/

Figure 23. Catholic Relief Services Senior Advisor, Geoffrey Heinrich, during a collaborative field visit in Chipata, Zambia, 3–6 April 2018.Photo credit: Christian Thierfelder/CIMMYT.

Africa RISING Global Climate Change Mitigation (Zambia)

(Impact of Sustainable Intensification on Landscapes and Livelihoods, SILL)

The project will be ending in November 2018. Progress and achievements during the reporting period primarily involved:

i. Organizing a workshop in Lusaka on energy security: the project team organized a workshop on energy security to discuss the revised model and project findings in Lusaka, 26–28 June 2018. Participants included partners from the University of Zambia and other researchers.

ii. Presentation of findings to village headmen in Eastern Province: the findings of the project were presented to a group of village headmen and headwomen in Eastern Province, 29 June 2018.

iii. Presentations at scientific conferences and other scholarly outlets: the project team delivered several presentations on the objectives, methods, and results of the project to several audiences, including an invited presentation by R. Richardson on the project results at the Institute for African Development Seminar Series, Cornell University, Ithaca, New York, 6 September 2018, entitled "Energy security and sustainable livelihoods for southern Africa."

SIIL system dynamics model with data from ILUA II report
The system dynamics model developed in the first phase of the project has now been updated with data from the Integrated Land Use Assessment II report, which was released in late 2017. The model results from the more recent report have been incorporated into publications and presentations, including presentations to be included in the final report.

The project team has one forthcoming manuscript that has been accepted for publication, but is currently in the final stages of revision:

- Richardson, R. B., L. Schmitt Olabisi, K. B. Waldman, and N. Sakana. 2018. Using participatory system dynamics modeling of agricultural-environmental systems in a developing country context. In: *Innovations in Collaborative Modeling*, M. McNall, ed. In press, Michigan State University Press.

The project team has one draft manuscripts under revision:

- Richardson, R. B., L. Schmitt Olabisi, K. B. Waldman, N. Sakana, and N. Brugnone. 2018. Modeling the landscape-level implications of farm-level sustainable intensification in Zambia. In preparation for submission to *Agriculture, Ecosystems and Environment*.

The full report of this project covering the period April 2014 to November 2018 is due in December 2018.

Capacity building

Various short-term capacity building activities were implemented during the reporting period as shown in Table 18.

Table 18. Short-term training, and field days, offered in ESA projects during April–September 2018.

Subject of training/Field day	Lead institution	Venue	Participant category	Number of participants	Women (%)
Short-term training					
Forage production and feed processing	ILRI	Babati, Tanzania	Farmer trainers	30	37
Poultry production	ILRI	Babati, Tanzania	Farmers	50	45
Standard operating procedures in seed management	ICRISAT	ZARI Masekera, Zambia	ZARI Officials, Seed inspector, FoF MD	9	22%
Legume seed production and crop management	ICRISAT	Chipata, Katete, Lundazi, all in Zambia	Farmers	153	69
Postharvest management	MSU	Ntubwi, Nsanama, Nyambi, all in Malawi	Farmers	425	68
Postharvest management	IITA	Karatu, Tanzania	Farmers, Extensionists	213	34
Field days					
Annual field tour to the Doubled-up legumes trial	CIMMYT	Chanje Camp, Zambia	Multiple stakeholders	39	44
Annual field tour to the Doubled-up legumes trial	CIMMYT	Hoya, Zambia	Multiple stakeholders	31	23
Field day at the Doubled-up legumes trial site	CIMMYT	Hoya, Zambia	Multiple stakeholders	75	43
Field day at the GMCC site	CIMMYT	Magodi, Zambia	Multiple stakeholders	177	40
Field day at the Doubled-up legumes trial site	CIMMYT	Kapara, Zambia	Multiple stakeholders	277	34
Farmer evaluation of doubled-up legumes	CIMMYT	Kapara, Zambia	Multiple stakeholders	29	45
Annual field tour to the doubled-up legumes trial	CIMMYT	Mtaya, Zambia	Multiple stakeholders	41	49

Annual field tour to the doubled-up legumes trial	CIMMYT	Kawalala, Zambia	Multiple stakeholders	30	43
Community awareness meeting	CIMMYT	Kawalala, Zambia	Multiple stakeholders	16	1
Poultry management	ILRI	Matufa and Hallu, Tanzania	Multiple stakeholders	400	43
Legume seed production and crop management	ICRISAT	Chipata, Lundazi, Katete, all in Zambia	Multiple stakeholders	460	44
Field days and farmer feedback	MSU	Linthipe, Malawi	Multiple stakeholders	634	62

Challenges and proposed actions

One of the weather stations that was collecting data at the vegetable hubs with irrigation work in Seloto was vandalized and stolen. This issue was reported to the Police and they are following up with the case. Unfortunately, the dataset for analysis had not been downloaded when this incident happened. Although there will be no replicate data for the 2 months of lost data, we shall compensate by using a surrogate dataset from the automated SAROS readings, which were taking microclimatic variables at the same site. Steps to prevent extreme data loss include more frequent data downloads from sites and also exploration for remote data access through the Cloud.

Preventive steps against vandalism will require more levels of vigilance, including involving local traditional leaders. We shall explore using wire mesh fences for weather stations that do not have this level of protection.

ICRISAT was unable to find any agency that could be engaged for multiplying early generation seed in Kongwa and Kiteto. Due to the legal requirements for production of the early generation seed, especially of nuclear breeder seed, ICRISAT multiplied these on-station in Nairobi and as a winter crop in Malawi. Basic seed a class of early generation seed of pigeonpea was produced in partnership with Dry Land Agriculture Investment Limited (DIAL).

Timeliness and quality of partner reports continue to be an issue, despite sending reminders and complaints to the management of the partner institutions and not only to the scientists. It seems that the low funding levels of the past year has not increased the motivation of partners.

The late information about new funding (July 2018) led to a delay in organizing a meeting with all partners to review progress and plan for the new field season. This meeting will be held at the beginning of October. However, it can be anticipated that work plans and partner agreements will not be completed before December, presenting a challenge for partners being prepared at the start of the field season in the project countries.

Communications and knowledge sharing

The main communication channels supported during the reporting period were:

- Wiki internal workspace: http://africa-rising.wikispaces.com/
- Project updates on the program website: https://africa-rising.net/
- A Yammer network with internal updates
- Photos: https://www.flickr.com/photos/africa-rising/
- Repository: https://cgspace.cgiar.org/handle/10568/16501

WikiSpaces, the platform which hosted the Africa RISING wiki over the past 7 years was closed on 31 September 2018. This prompted the communication and knowledge management (CKM) team to migrate all the content previously uploaded on the old wiki platform to a new one which is managed by MediaWiki. All content was successfully migrated; however, the switch caused a lot of link breakage and formatting loss to the content. In the coming months, the team will be focusing on ensuring that the new wiki platform is up and running and continues to serve knowledge sharing and management needs of the Africa RISING program. The web address of the newly migrated wiki site is: http://africa-rising-wiki.net/Home

The following meetings and events were held and documented on the wiki:

- 3–5 October: Africa RISING ESA Project Review and Planning Meeting - Lilongwe, Malawi
- 27 September: End-of-Project meeting for Africa RISING going to scale in Eastern Province of Zambia Project - Chipata, Zambia
- 26–27 June: Africa RISING - NAFAKA annual review and planning meeting - Dar es Salaam, Tanzania
- 14 June: Extension and producer organization leaders post-harvest training on grain quality standards - Mbeya, Tanzania
- 24–25 April: Africa RISING ESA & WA projects joint strategic planning meeting - Livingstone, Zambia
- 5–12 March: Africa RISING - SIIL Joint field visit to Tanzania (different sites AR & SIIL project sites) - Tanzania

The stories listed below were published and disseminated to stakeholders concerning different project's activities and outputs. Click on hyperlinked titles below to view.

- Focus on achieving wider impacts and building resilience for larger populations, Africa RISING urged (17 October 2018)
- What sustainable intensification of mixed farming systems looks like in Tanzania (27 August 2018)
- Growing an improved rice variety without applying good agricultural practices is like having a bicycle with a flat tire (6 August 2018)
- The value of systems research—reflections from Africa RISING partners (11 June 2018)
- Africa RISING Phase I—what it took, what it gave, our proudest achievements (6 June 2018)
- Footprints of Africa RISING—looking back at achievements from Phase I (2011-2016) (1 June 2018)
- Africa RISING Feed the Future SI Innovation Lab joint field visit to Tanzania (18 May 2018)
- Zambia RISING: a photo report of project activities during the 2017/18 cropping season (10 May 2018)

- Malawi RISING: a photo report of project activities during the 2017/18 cropping season (7 May 2018)
- A note from the European Geosciences Union General Assembly 2018 (23 April 2018)
- Lessons from Tanzania on the benefits of collaboration in Africa RISING (11 April 2018)
- Africa RISING, SIIL and SIMLESA hold joint learning event on sustainable intensification and farming systems research in agriculture (5 April 2018)

The CKM team also published the "Footprints of Africa RISING" report - a summary of the achievements by the program in its first 5-year phase (2011–2016). In addition to a well-planned and executed online dissemination of the report, 1000 hard copies were also printed and distributed amongst key stakeholders in Tanzania, Malawi, Zambia, Ethiopia, Ghana, and Mali.

Selected reports and publications

The following peer reviewed journal articles and reports were published by the project team during this period.

Peer reviewed journal articles

- Abass, A. B., Fischler, M., Schneider, K., Daudi, S., Gaspar, A., Rüst, J., ... & Msola, D. (2018). On-farm comparison of different postharvest storage technologies in a maize farming system of Tanzania Central Corridor. Journal of Stored Products Research, 77, 55-65.
- Sseguya, H., Bekunda, M., Muthoni, F., Flavian, F. & Masigo, J. (2018). Training transfer for sustainable agricultural intensification in Tanzania: critical considerations for scaling-up. Journal of Agricultural Science and Technology, 20, 661-671.
- Lukumay, P.J., Afari-Sefa, V., Ochieng, J., Dominick, I., Coyne, D. & Chagomoka, T. (2018). Yield response and economic performance of participatory evaluated elite vegetable cultivars in intensive farming systems in Tanzania. Acta Horticulturae, 1205, 75-86.
- Gramzow, A., Sseguya, H., Afari-Sefa, V., Bekunda, M. & Lukumay, P.J. (2018). Taking agricultural technologies to scale: experiences from a vegetable technology dissemination initiative in Tanzania. International Journal of Agricultural Sustainability, 1-13.

Reports

- IITA. 2018. Sustainable intensification of key farming systems in East and Southern Africa: Technical report, 01 October 2017 – 31 March 2018. Ibadan, Nigeria: IITA.
- Munthali, W. and Okori, P. 2018. Community seed banks in Malawi: An informal approach for seed delivery. Ibadan, Nigeria: IITA.
- Gundula, F., Jimah, K. and Wittich, S. 2018. Africa RISING East and Southern Africa and West Africa projects – annual gender report 2017. Ibadan, Nigeria: IITA.
- IITA and ILRI. 2018. Footprints of Africa RISING—Phase I: 2011–2016. Ibadan, Nigeria: IITA.
- IITA. 2018. Enhancing partnership among Africa RISING, NAFAKA and TUBORESHE CHAKULA Programs for fast tracking delivery and scaling of agricultural technologies in Tanzania: Quarterly Report (01 October 2017–31 December 2017). Ibadan, Nigeria: IITA.
- Odhong, J. 2018. Photo report: Africa RISING management team field visit to Zambia, February 2018. Ibadan, Nigeria: IITA.
- Odhong, J. 2018. Photo report: Africa RISING management team field visit to Malawi, February 2018. Ibadan, Nigeria: IITA.